LECTURES
ON
DIETETICS & DYSPEPSIA

WILLIAM ROBERTS, M.D., F.R.S.

BY THE SAME AUTHOR.

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A PRACTICAL TREATISE on URINARY and RENAL DISEASES, including URINARY DEPOSITS. By WILLIAM ROBERTS, M.D., F.R.S., Fellow of the Royal College of Physicians, London; Professor of Medicine at the Victoria University; Consulting Physician to the Manchester Royal Infirmary. Assisted by ROBERT MAGUIRE, M.D. Lond., Member of the Royal College of Physicians, London; Physician to Out-patients, St. Mary's Hospital, London; late Pathologist to the Manchester Royal Infirmary.

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DIETETICS AND DYSPEPSIA

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ON

DIETETICS AND DYSPEPSIA

DELIVERED AT THE

Owens College School of Medicine

IN

FEBRUARY AND MARCH 1885

BY

WILLIAM ROBERTS, M.D., F.R.S.

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PREFACE.

These Lectures were delivered as a special course to practitioners and students at the Owens College in the spring of the present year, 1885. They do not pretend to be in any sense systematic. They are the fruit of some desultory laboratory work, and of reflections relating to the subjects of dietetics, digestion, and dyspepsia.

The second, third, and fourth Lectures (which in actual delivery were compressed into two) contain a record of a series of experimental inquiries into the effects of our food-accessories on the chemical acts of digestion. These are only loosely connected with the subjects dealt with in the first and fifth Lectures: indeed, the connection is more in the continuity of study than in the relation of the subjects discussed.

Notwithstanding their disconnected character, I trust these Lectures will not be unacceptable to the medical profession. They treat of subjects which are perhaps somewhat neglected in these days, and in regard to which there is a conspicuous want of accurate information.

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LECTURE I.

INTRODUCTORY—ON DIETETICS IN GENERAL.

SUMMARY:—Dyspeptic troubles more common in man than animals—Causes of this—Complexities of the human dietary—Science of dietetics based on observation of food-customs—Food-customs of leading races—Use of meat—Alcoholic beverages—Tea, coffee, and cocoa—Dietetic habits of the two sexes—Secondary dietetic habits for the young and for the aged—Effect of the quality of the food on nutrition and vital habits—High feeding and low feeding—Comparison of characteristics of high-fed and low-fed classes and races—Calculating the man-value—Connection of mental capacity with nutrition.

GENTLEMEN,—

DEFECTS and derangements of digestion are among the most common of human ailments. They not only complicate almost every variety of disease, but they constitute by themselves a serious torment to a large number of otherwise healthy people. Not a few of those who bear a large and vigorous part in the world's work, and may-hap reach a green old age, are plagued half their days with dyspeptic troubles. These unfortunates have no sooner reached the full adult state, and have ceased to grow and gather weight, than they enter on a period of gastric discord, in which there seems to be a permanent want of due adjustment between their digestive functions and their food supplies. Besides these habitual dyspeptics there are also a multitude of others, also healthy, who are liable to frequent paroxyms or fits of indigestion. Any unusual worry or anxiety, or any trifling irregu-

larity in the quantity, quality, or order of their meals, disturbs the tranquillity of their digestive processes.

The digestion of food is, as you know, at bottom perhaps the most simple of all our functions: it can be imitated with remarkable precision, in a glass vessel in a laboratory experiment. The articles of our food likewise consist, fundamentally, of a few common alimentary principles, which can be counted on the five fingers—proteid substances, collagenous matters, starchy and saccharine compounds, and fat. Both in regard to his digestive juices and the alimentary principles submitted to their operation, man does not differ in any essential particular from the lower animals, and yet it would seem as if the function of digestion were less perfectly adjusted, and its equilibrium more easily disturbed in man than in the lower animals. The cause of this discrepancy is to be sought partly in the quicker and more universal sympathies of his nervous system, and partly and chiefly, in the extraordinary complexities which civilised man has introduced into his dietary. He has departed widely, and is departing more and more, in regard to his food, from the simplicity and uniformity of his primitive nature. Scarcely any two of his meals are exactly alike [1]—and although the adjustive power of his digestive organs keeps pace in the main with this increasing complexity, the process of adjustment in many individuals seems to lag a good deal behind their requirements.

The first class of complications with which our

[1] This variability or diversity is a marked characteristic of the diet of the civilised races. Not only do the several daily meals—breakfast, dinner, &c.—differ from each other, but among the easier classes the breakfast or dinner of one day generally differs more or less from the corresponding meal of another day. Animals in a state of nature exhibit little or none of this diversity—their diet is generally wholly monotonous.

digestive organs have to deal are those arising from the elaborate preliminary preparations, and especially the numerous cooking processes, to which our food is subjected. In regard to a large part of our food the process of cooking is an absolute necessity ; we have no power of digesting farinaceous articles without previous cooking, and the same may be said of the collagenous tissues of animal flesh. But although we speak of cooking as if it were a definite change impressed on articles of food by means of heat, the degree of cooking differs greatly. We boil or roast animal flesh to varied degrees, and in the preparation of cereal articles there is very great difference in the degree of cooking. A well-boiled gruel may be said to be fully cooked, and well-baked bread may be said to be highly cooked, but pastry is usually very imperfectly cooked. The complexity thus introduced obviously renders the task of adjustment in our digestive organs more difficult than if our diet were of a more uniform character. Again, we use a number of condiments with our food to which the lower animals are strangers—salt, vinegar, curries, spices and sauces of all sorts.

But by far the most remarkable departure on the part of man in regard to his food, from the common ways of the animal world, is the practice he has acquired of using in large quantities certain articles of a stimulant or restorative character, of which the chief are alcoholic beverages, and tea and coffee. These articles are not themselves endowed with nutrient properties ; but inasmuch as they are taken with food, and mingle therewith in the digestive passages, they directly complicate the task of the digestive organs, as we shall see further on.

There are therefore in the study of human digestion

problems of great interest and importance which we do not encounter at all in the study of the digestion of the lower animals; and I propose, in the course of these lectures, to examine in some detail the effects of alcoholic beverages, and of tea and coffee, and of one or two condiments, on the processes of digestion.

But before coming to this subject, I have some observations to make, of a somewhat fragmentary character, having reference to dietetics in general.

The science of dietetics must, I apprehend, be mainly based and built up on an observation and a study of the practices and customs of mankind in regard to their food, rather than upon any *à priori* data supplied by physiology. In the case of the lower animals, we assume that each creature selects, from the nutrient materials within its reach, those articles which are most suited to its well-being, and are best fitted to promote its success in the struggle for existence, and that it is guided in this selection by an almost unerring instinct. This, like other instincts, is now explained by biologists as consisting essentially in an inherited experience, which has been gradually accumulated through a long line of ancestors, and is transmitted by heredity to the descendants.[1] Accordingly, when we see an animal feeding on a particular kind of food, we conclude without hesitation that that food is, of all the nutrient materials

[1] In agreement with this explanation, it is found that when animals are placed under circumstances which are new to them, and which are beyond the teaching of any possible ancestral experience, their food-instincts fail them. Thus, animals can be easily poisoned by the artificial mixture of poisonous substances with their food, and cattle newly introduced into strange pastures in quarters of the globe far distant from their native soil are liable to be poisoned by strange herbs, which, however, after a time they learn to avoid.

accessible to it, the best adapted for the special wants of its economy. But we know that man, in regard to his bodily functions, is subject to the same laws as govern the life of the lower animals. And we cannot doubt that in the formation of his dietetic habits man is guided by the same kind of instincts as those which guide the rest of the animal creation in the choice of their food.

The generalised food-customs of mankind are therefore not to be viewed as random practices adopted to please the palate or to gratify an idle or vicious appetite. These customs must be regarded as the outcome of profound instincts, which correspond to important wants of the human economy. They are the fruit of a colossal experience, accumulated by countless millions of men through successive generations. They have the same weight and significance as other kindred facts of natural history, and are fitted to yield to observation and study lessons of the highest scientific and practical value.

In taking dietetic customs as objects of study it is obvious that widely disseminated customs, followed by many races and by vast masses of population, have a deeper and wider significance than customs limited to small communities or to isolated families or individuals. It is also obvious that the practices of the more successful races, and of the easier classes of a nation, are more likely to yield good dietetic models than the practices of backward races, or of the poorer classes. Because the former, owing to their ampler means, have greater freedom of choice, and because also their greater success in the struggle for predominance is *primâ facie* evidence of the beneficial tendency of their food-habits. I need hardly say that dietetic customs which are not the outcome of the free choice of the population, but are the

consequence of legislative enactments or of religious injunctions, are of no utility as guides in the study of dietetics—except, indeed, as warnings of the mischief that may accrue from ignorant meddling.

The British races and the other races of Western Europe, together with their descendants in different parts of the globe, are, on the grounds just stated, fitted to supply us with a body of dietetic customs which may be regarded as a beneficial model. These races and nations are, on the whole, but especially in intellectual power, far in advance of all others. Their food-customs have grown up spontaneously, without material interference from legislator or religious reformer. Their world-wide commerce has brought cheaply to their doors the products of every land and every clime, and has enabled them to exercise a greater freedom of selection than has been possible to any other races.

The salient characteristics of the diet of the Western races may be expressed in a few words. It consists partly of cereal and farinaceous articles and fruit, and partly of animal flesh. The use of alcoholic beverages is almost universal among them, and they consume, in large quantity, tea, or coffee, or cocoa, or all three. I propose to make a few remarks on each of these characteristics.

THE USE OF MEAT.

It has been estimated that among the easier classes in Western Europe about one-fourth of their food consists of meat or fish, and three-fourths of vegetable articles and fruit. In this, our own country, the consumption of meat is considerably larger than on the Continent of Europe.[1]

[1] The consumption of meat per head per annum is estimated as

This consumption is also steadily increasing. The increase, however, is not due to any change of habits among the easier classes, but to an increasing use of meat among the working classes. As wages improve the diet of the working classes tends to become more and more assimilated to that of the easier classes. Among the latter it may be said that a state of stable equilibrium in regard to this point has been attained, or at least approached, and that meat constitutes as large a part of their dietary as it is likely to reach. But with the larger part of the population this is far from being the case. Meat is a dear form of food. In regard to proteid matter, lean beef contains, roughly speaking, twice as much as wheat flour, but beef is about four times as dear as flour, so that you may estimate that proteids of animal source are about twice as costly as proteids of vegetable source. The want of means among the poorer classes prevents this part of the population from indulging in meat to the full length of their desires. The proportion of meat which enters the households of the easy classes is greatly in excess of that which enters the households of the less affluent. We should not probably be far out in estimating that, if the entire population consumed as much meat per head as do the wealthier portions, the total consumption of meat in this country would be increased threefold.

136 lbs. in England, 46 lbs. in France, 35 lbs. in Prussia, and 84 lbs. in Belgium. It is larger in cities than in rural districts, and is largest of all in London.—Kolb. *Condition of Nations*, English translation, p. 961.

THE USE OF ALCOHOL.

The use of alcoholic beverages is a marked characteristic of the diet of the European and other progressive races. The vast populations of Asia, with the exception of the Japanese [1] and the Indian Parsees,[2] are almost non-alcoholic in their habits. This is largely due to the prevalence of the tenets of Islam throughout Asia and the injunctions against the use of wine in the Mahommedan system. There is an impression that the British races enjoy a bad pre-eminence for their use of alcohol. But this impression is not borne out by exact inquiry. It would appear from the most reliable statistical returns that there is a considerable uniformity in the consumption of alcohol, per head of the population, among the nations of Europe. Mr. Mott estimates the average consumption of alcohol among the civilised nations as between four and five gallons of proof spirit per head per annum.[3] But although the total consumption of alcohol in this country be not excessive for the entire population, a larger number of individuals take an excessive quantity

[1] Saké, the national beverage of the Japanese, is a kind of strong beer, containing about 10 per cent. of alcohol, brewed from rice by a peculiar method, quite different from the processes used in Europe. The consumption of saké in Japan is on a very large scale, and the Government derives about a sixth of its revenue therefrom. Mr. R. W. Atkinson, formerly Professor of Chemistry in the University of Tokio, estimates that the Japanese consume per head about one-third as much alcohol in the form of saké as is consumed in England in the form of beer. Saké brewing is known to have existed on a large scale in Japan for 300 years.—Memoirs of the Science Department of the Tokio University, No. 6. *The Chemistry of Saké Brewing*, by R. W. Atkinson, printed at Tokio, 1881.

[2] The habits of the Indian Parsees in regard to the use of alcohol seem to resemble those of temperate Europeans.—See *History of the Indian Parsis*, by Dosabhai Framji Karaka: London, 1884.

[3] A. J. Mott.—*National Review*, May, 1884, p. 296.

than is the case among most of our neighbours across the Channel.

There are certain inferior races who appear to be altogether intolerant of alcohol. Either it does not suit their type of nutrition or they lack the self-control which is necessary to its beneficial use. The Indians of North America are said to be excited almost to madness by any use of alcohol, insomuch that the Colonial authorities forbid, under heavy penalties, the giving or selling of alcoholic liquors to the native tribes. The Ainos of Yezo, a subject race inhabiting the northern island of Japan, appear to be wholly wanting in self-control in the use of alcoholic stimulants, for which they evince an irrepressible passion. Whenever they have the opportunity, both the men and the women drink themselves to a state of insensibility.[1] The defective reaction of these races towards alcohol may be compared to a similarly defective reaction in certain individuals and certain families among ourselves.

THE USE OF TEA, COFFEE, AND COCOA.

Within the last two centuries an important change has taken place in the dietetic customs of the European nations through the introduction of tea, coffee, and cocoa. The use of these beverages has spread rapidly among the populations, and at the present day they are articles of large and almost universal consumption. In this country all three beverages are in common use side by side, but tea takes a large and increasing lead, especially among the working classes. On the Continent the use of one or other of these beverages prevails almost to the exclusion of the rest; in France and Germany coffee prevails,

[1] *Unbeaten Tracks in Japan*, by Miss Bird, vol. ii.

in Russia tea, and in Spain and Italy cocoa or chocolate.

The introduction of these articles constitutes, without doubt, the most remarkable dietetic revolution witnessed among men in historic times. Within the last hundred years the use of these beverages has become so large and so general that we may fairly assume that a sufficient time has elapsed to enable us to form a judgment of their effects on national characteristics. That the effects have not been injurious to the nations of Europe is demonstrated by the continued progress of these nations, and their increasing ascendency among the nations of the world. It is scarcely possible that so important and so peculiar an addition to our dietary has not had some effect on the type of nutrition, and more particularly on the nutrition of the brain and nervous system. Reflecting on this matter, I have not been able to avoid the impression that it is possible to trace a change in the mental type of the Western races in the last three generations. There is, I think, to be observed an increased precision in their mental operations, resulting in an improved criticism, and in the rise and progress of the exact sciences. It is certainly remarkable that within the last century, coincident with the spread of tea, and coffee, and cocoa, and perhaps I should add tobacco, and in combination with the ancient usage of alcohol, there has been, within this brief epoch, more progress made in criticism and the exact sciences and the dependent industrial arts, than in all the preceding ages of this world; whereas, during the same epoch, art and literature, which depend more on the imagination, have practically stood still. The coincidence is at least suggestive.

It is to be noted that (at least among the English-speaking communities) the general custom with regard to

tea and coffee is to take these beverages in the morning and afternoon, whereas with regard to alcohol the custom is reversed. As a rule, alcoholic beverages are not taken before the midday meal, and the larger portion of the daily consumption is reserved for the last meal and for the period intervening between that meal and bed-time. The reason of this is obvious. Tea and coffee tend to promote wakefulness; alcohol, on the other hand, in the second phase of its effects, tends to lethargy and the promotion of sleep.

DIETETIC HABITS OF THE TWO SEXES OF INFANTS AND CHILDREN AND OF THE AGED.

There is a clear difference to be discerned in the dietetic habits of the two sexes. There are no available statistical data to go upon; but from common observation we cannot fail to note that men eat much more meat than women. Probably we should not err in estimating that two-thirds of the meat brought to market is eaten by the men, and only one-third by the women. In regard to alcohol, the contrast is still more marked. My impression is that, in this country, three-fourths, if not four-fifths, of the alcohol is consumed by men, and only one-fourth or one-fifth by the women. On the other hand, the consumption of tea and coffee—but especially of tea—is markedly more abundant among women than among men. The comparison is completed when we add that women consume, in proportion to the totality of their food, more milk and more bread than men do.[1]

[1] If I am not mistaken, these contrasts in the diet of the two sexes are more pronounced in this country than in most others; and there is, perhaps, to be observed a corresponding breadth of contrast between the characteristics of the two sexes—the men being less effeminate and the women more womanly with us than among some other populations.

Alongside the main dietetic habits established for the profit of the operative mass of the community there are secondary habits formed for the use of infants and children, and for persons advanced in years. With regard to infants and children, we observe that they are not allowed to partake of the accessory articles of food which form so conspicuous a part of the dietary of their elders. They are allowed neither the use of alcohol nor of tea and coffee, except gradually as they draw towards the adult age, but are fed on simple nutrients—milk, cooked cereals, and more or less meat.

With advancing years the diet undergoes a certain modification. The consumption of meat is, I think, generally lessened, and the consumption of milk and cooked cereals proportionally increased. In regard to alcohol, the modification of habit seems to vary with the preceding practice of the individual. Persons who have been in the habit during their prime of taking a full allowance of stimulants gradually diminish the proportion as age creeps on, and their nutritive processes decline in elasticity and power. Sometimes the indications of this natural tendency are neglected or resisted by the unwary; they imagine that the quantity of stimulants which they tolerated with impunity, or even took with advantage, during the vigour of manhood cannot hurt them in later life. This, I believe, is an error the commission of which tends to accelerate senile decay and to provoke fatally tending organic changes in the kidneys, liver, and arterial system.

On the other hand, persons who during their youth and prime have only used alcohol occasionally, or have abstained entirely from it, find advantage in their declining years in a more systematic use of wine or spirits.

It is important to remark that the main dietetic customs of a country are instituted for the benefit of the robust and healthy, of the sober and temperate, and those of mean or average constitution; in other words, for those who are bearing the burden of the day and fighting the battle of life. These form the great mass and bulk of the adult population, upon whose bodily and mental efficiency national progress and ascendency depend. A good many individuals, and even entire families, may not find these customs beneficial to their exceptional tendencies or weaknesses; they may even find them destructive to their health and life; but here as elsewhere, and indeed universally, in Nature's operations the individual is sacrificed to the welfare of the community—

> So careful of the type she seems,
> So careless of the single life.

It would not appear to be the part of wisdom to depart without some solid reason from the dietetic customs of the country. We may be quite sure that the use of meat and of alcoholic beverages, and of tea and coffee, subserve some useful purposes to the human economy; though we, in our ignorance, may not be able to specify them with precision. These customs are the spontaneous outcrop of natural instincts and the fruit of an immense experience; and the sanction they derive therefrom constitutes an incomparably weightier authority than any other we possess.

Nevertheless differences of constitution and personal idiosyncrasies have to be reckoned with; and there are frequently good, indeed paramount, reasons why individuals should, in some particular or other, depart from the general dietetic plan. I have known a few natural-

born vegetarians who have had a life-long distaste for meat.[1] Some persons are intolerant of tea, others are intolerant of coffee. It is, however, with respect to alcohol that the most important deviations from the mean type of constitution occur. Some persons are made uncomfortable by the most sparing use of alcohol, either throughout their life or at some epoch of it. A good many also are wanting in that self-control which is necessary to the salutary use of this stimulant. These peculiarities or idiosyncrasies must be attended to. It may be regarded as certain that any food or food-accessory the use of which is followed by a sense of discomfort is not beneficial to that individual. Persons who are unable to take alcohol in moderation should, on pain of loss of health and life, altogether abstain from its use, for to them it is easier to abstain than to be abstemious.

EFFECT OF THE QUALITY OF THE FOOD ON NUTRITION AND VITAL HABITS.

There are some very subtle and exceedingly curious relations between the quality of the food and the nutrition and vital habits of the body. They are profoundly difficult to understand, and yet are absolutely authentic and highly important. One would think that so long as an animal obtained his due quantity of proteids, carbohydrates, and fats, it did not matter much from what source they were obtained. But this is far from being the case. There are differences in effect not only between animal and vegetable articles of

[1] It is not very uncommon to meet with children who have an aversion to meat, and who require considerable training on the part of their parents to accustom them to its use.

food, but also between one kind of animal food and another, and between one kind of vegetable food and another.

A remarkable illustration of the effect of the quality of the food on nutrition is supplied by the honey-bee. It is well known that, when by some untoward accident a hive loses its queen, the community have the power of providing themselves with a new queen. This is effected in the following manner. They take one of the ordinary neuter eggs, which in the usual course would produce an imperfect female or 'worker' bee, and place it in a peculiarly shaped cell, and feed the larva when hatched with a peculiar kind of food which bee-keepers term 'Royal Jelly.' The ordinary worker larva only gets one meal—its first—of this dainty, and is afterwards fed with some coarser stuff, but the intended queen is fed throughout her larva-ship with royal jelly. The consequence of this difference of diet is that the larva so fed comes quickly to maturity, and, instead of turning out a neuter, turns out a fertile female, or queen-bee.[1]

Other illustrations are furnished by our domestic animals. Experience has taught trainers that the vital habits and qualities of horses and dogs are considerably modified by the nature of their food. The characteristics

[1] 'It is well known that hemp-seed causes bullfinches and certain other birds to become black. Mr. Wallace has communicated to me some much more remarkable facts of the same nature. The natives of the Amazonian region feed the common green parrot with the fat of large Siluroid fishes, and the birds thus treated become beautifully variegated with red and yellow feathers. In the Malayan Archipelago, the natives of Gilolo alter in an analogous manner the colours of another parrot, namely, the *Lorius garrulus*, Linn., and thus produce the *Lori rajah*, or King-Lory. These parrots in the Malay Islands and South America, when fed by the natives on natural vegetable food, such as rice and plantains, retain their proper colours.'—Darwin, *Animals and Plants under Domestication*, vol. ii., p. 269.

of each strain are transmitted by heredity, but in order that they may be maintained in perfection the offspring must be fed with appropriate food. Trainers will tell you that the hunter and the draught-horse require to be fed differently. The hunter is bred and fed for speed and carrying power; the draught-horse for bulk and strength. In the hunter is wanted rapid liberation of energy within a comparatively short space of time; in the draught-horse is wanted a more gradual liberation of energy and for a longer period. To bring out their qualities each strain must be fed appropriately. The hunter is fed on a concentrated and stimulating form of food—chiefly on the heaviest and most expensive oats—which, if I may so express it, is the 'beef' of the vegetable feeders; and, unless he is so fed, he will not perform satisfactorily in the hunting-field. The draught-horse is fed on a lower and less stimulating diet—on Indian corn and chopped hay,—food which tends to increase bulk and weight.

Slow-going sporting dogs—setters and harriers—are fed chiefly on oatmeal and weak broth, but the coursing greyhound is trained on the very best of beef and mutton; and if these distinctions in the feeding are not observed neither kind comes up to its best performances.

These differences are expressed in popular phrase by saying that the hunter and the coursing greyhound are 'high-fed,' and the draught-horse and sporting-dog are 'low-fed.' The same kind of distinction may be drawn in regard to the diet of different members of the human family; some are high-fed and some are low-fed. Speaking generally, it may be said that high-feeding, in the case of man, consists mainly in a liberal allowance of meat and in the systematic use of alcoholic beverages, and that low-feeding consists in a diet

which is mainly vegetarian and non-alcoholic. On the ground of this distinction it may be said that the European races are more highly fed than the Asiatic, that the British races are more highly fed than the continental races, and that the inhabitants of London (owing to their large consumption of meat) are the most highly fed population in the world. The easier classes are more highly fed than the poorer classes, the town artisan is more highly fed than the agricultural labourer.

In drawing this contrast between high feeding and low feeding, the distinction has reference solely to the quality and not to the quantity of the food—to its comparative stimulating properties and concentration. It should also be remarked that it is the every-day habit that determines the character of the diet, and not occasional indulgence. A man may drink alcohol to excess or gorge himself with meat once a week or now and then, and yet have a low general standard of diet. Another man may be a spare liver, but if he take regularly, meat three times a day, and drink daily of high class wines or spirits, even in the most modest proportion, his diet must be ranked as high. There are distinctions also to be drawn in regard to the several kinds of meat and the several kinds of vegetable articles used. Beef and game should probably be ranked as higher diet than poultry and fish—and oats and wheat as higher than rice and potatoes.

If we compare, as best we may with our limited information, the general characteristics of the high-fed and low-fed classes and races, there is, I think, to be perceived a broad distinction between them. In regard to bodily strength and longevity the difference is inconsiderable; but in regard to mental qualities the distinction is marked. The high-fed classes and races display on the whole a richer vitality, more momentum and individuality of

character, and a greater brain-power, than their low-fed brethren; and they constitute the soil, or breeding-ground, out of which eminent men chiefly arise.[1]

In calculating what may be termed the 'man-value' of individuals, classes, or races, physical qualities count for relatively little. One man may be twice as strong, or twice as big, or possess twice as much muscular endurance, as another; but the difference of value scarcely goes beyond, and rarely even reaches, this proportion. But the possible difference between the mental capacity of one man and another is immense, almost incalculable. If you try to assess and to compare the value or capacity of a man of eminence—whether it be eminence in art, literature, science, statesmanship, commercial enterprise, colonising aptitude, military command, or any other outcome of brain-power—with the value and capacity of an average man, you perceive at once that the proportion is not as two to one—but as ten or twenty to one, or even as a hundred or more to one.

Galton, in his interesting and original work on 'Hereditary Genius,' gives a telling illustration of the possible degree of difference in mathematical capacity between different individuals. He takes the number of marks given to the several candidates in the examination for mathematical honours at the University of Cambridge, and shows that the senior-wrangler exhibits a mathematical capacity thirty or thirty-two times greater than the lowest on the list of honours; and this last must be credited with a mathematical capacity many times greater than that of the average undergraduate.

Differences in mental capacity are referrible on ulti-

[1] It is remarkable how often we hear of eminent men being troubled with gout, and gout is usually produced either by personal or ancestral high feeding.

mate analysis to differences in the type of nutrition of the brain-cells; and nutrition, as we have seen, is influenced in a very subtle manner by the quality of the food. It is to be borne in mind that, a certain type of nutrition having been acquired, it tends to become intensified and fixed by a continuance of the conditions which originated it, and to be transmitted by heredity. The effects of dietetic habits are not therefore made fully apparent in a short time, nor are they easily nor soon nullified by a change of diet. Gout furnishes an illustration of these propositions. Gout is a type of nutrition liable to be acquired by persons who indulge in a certain kind of high feeding. The gouty tendency gradually grows under a continuance of the gout-producing diet, until at length it reveals its presence in an arthritic attack. But a person so afflicted cannot easily nor soon throw off his gout by reverting to a low scale of feeding; it is often stamped on his constitution for life, and is handed on to his posterity.

Similarly with types of nutrition produced by a low standard of diet. The effects of a vegetarian diet or of a non-alcoholic regimen would only be gradually developed, and would probably not be fully impressed on the bodily and mental qualities of the race until after such habits had been continued through two or three successive generations.[1]

[1] I have encountered in Salford, where, some years ago, there existed a flourishing colony of vegetarians, a tradition to the effect, that though vegetarianism might suit the parents it was bad for the children. And I have seen some striking examples in that borough which appeared to indicate that this tradition was well founded.

LECTURE II.

EFFECT OF THE FOOD-ACCESSORIES ON SALIVARY DIGESTION.

SUMMARY:—Preliminary remarks—Richness of human saliva in diastase connected with the habit of cooking food—Method of experimentation—Effect of alcohol and ardent spirits on salivary digestion—Wines—Vinegar—Malt liquors—Effervescent table waters—Tea and coffee—Tannin—Effect of carbonate of soda on tea, and of the effervescent table waters on wine—Beef-tea, salt, and sugar.

GENTLEMEN,—

HAVING disposed of these general considerations, I now turn to the examination of some of those problems which are special to human dietetics, and which are not presented to us at all in the study of digestion in the lower animals. We have seen that the civilised races are in the habit of using with their food certain accessory articles of a stimulant or restorative character, which have no title to be regarded as nutrient substances. These form no part of the diet of the lower animals, nor are they necessary or essential to our own diet. Nevertheless they are consumed by us in enormous quantities, and at a prodigious cost.

What is the effect of these several accessories on the processes of digestion? Do they help, or do they hinder, or are they indifferent?

These are the questions I propose to consider. Digestion, as you know, is carried on in three successive stages or phases: in the mouth under the influence of

salivary diastase, in the stomach under the influence of pepsin and hydrochloric acid, and in the small intestine under the influence of the pancreatic juice. I shall take these stages in succession, and inquire in each case what is the effect of our various food-accessories on these several phases of the digestive process.

EFFECT OF FOOD-ACCESSORIES ON SALIVARY DIGESTION.

Salivary digestion consists in the transformation of starch into sugar. It takes place partly in the mouth during the process of mastication, and partly in the stomach on the arrival of the food in that viscus, and it continues to go on until the rising acidity of the gastric contents puts a final stop to diastasic action. The time of salivary digestion is therefore brief, and to be of any avail the action must be rapid. The digestion of starch by saliva is never more than partial, and seeing that the pancreatic juice lies in reserve in the duodenum, and that this has an intense amylolytic activity, it is obvious that starchy matters would not fail of being digested even if they were not subjected at all to salivary action. Some physiologists have even doubted, on the ground of observations on animals, whether the action of saliva on starch was of any importance. But it is to be remarked that human saliva is peculiarly rich in diastase, richer apparently than the saliva of any other animal. And this wealth of diastase, we may be sure, is not there for nothing. If salivary diastase were of no service, it would, in accordance with a well-known biological law, soon fall into abeyance and cease to be secreted. It can scarcely be doubted, I think, that the exceptional richness in diastase of human saliva has special relation to the habit man has acquired of cooking his food. Salivary diastase

is powerless on raw starch, but it acts energetically on starch which has been changed to a state of jelly or mucilage by previous boiling or baking. And if we consider how large a part of our food consists of bread and other cooked farinaceous articles, the importance of our exceptional salivary power will at once appear. The first step in amylolysis is to change starch jelly into soluble starch, and this first step is accomplished with extreme rapidity; and although it is only the initial act in the transformation of starch, the physical alteration so produced is very great and of important advantage in the subsequent stages of digestion. By this initial act the solid or semi-solid coherent starch jelly is transformed into a running liquid. Such articles as bread, pastry, and doughy puddings are altered considerably even by a brief contact with saliva. Their texture is rendered looser and more penetrable, and this change greatly facilitates the subsequent task of the gastric juice.

Method of Experimentation.—In testing the effects of food-accessories on starch digestion, I followed the method of diastasimetry described by me in a paper published in the Proceedings of the Royal Society for 1881. I operated on a 'standard starch mucilage,' which contained exactly 1 per cent. of dry starch.[1] 10 c.c. of this standard starch mucilage were diluted with 90 c.c. of water. This was called the 'digesting mixture.' To this was added 1 c.c. of filtered saliva, and the time of the addition was exactly noted. Digestion soon began and went on apace. From time to time a drop of the digesting mixture was placed on a white porcelain surface

[1] The 'standard starch mucilage' was always prepared from potato starch, which can be easily prepared in a state of great purity by repeated levigation, and drying at blood-heat. It can be obtained ready prepared from Mottershead & Co., chemists, Manchester.

and touched with a drop of solution of iodine. At first the well-known dark blue coloration was produced by the contact. In a minute or two the coloration produced was no longer blue but violet, in another minute it was fawn, and then very pale yellow, and finally in four or five minutes from the commencement of the experiment the abstracted drop gave no coloration at all with iodine; all the starch had been converted into colourless dextrine and sugar. The time when this occurred was exactly noted—this was called the 'achromic point.' The length of time required to reach the achromic point furnished a measure of the speed, or activity, of digestion. The experiments were always performed at or near blood-heat. When I wished to try the effect on starch digestion of a food-accessory, say tea, I added a known quantity of the infusion to the 90 c.c. of dilution water, or rather I included it in this, so that the total digesting mixture always amounted to 100 c.c. The single cubic centimetre of saliva was next added.[1] I could then see, by the length of time required to reach the achromic point, whether the addition I had made hastened or retarded digestion or was indifferent. Operating in this way I tested the effect on salivary digestion of varying proportions of alcohol, wines, tea, coffee, salt, vinegar, &c.

ALCOHOLIC BEVERAGES.

Alcohol and the Distilled Spirits.—Alcohol was used as 'proof spirit' containing exactly 50 per cent. of absolute alcohol. The whisky was marked 'proof'—the brandy was 10 under proof. Gin was found to have nearly the same effect as a watery dilution of corresponding

[1] The same specimen of saliva was always employed for the same set of experiments. Specimens of saliva from the same individual were found to vary very little in diastasic power.

alcoholic strength. I have not therefore thought it necessary to give separately the results obtained with gin. The following table exhibits the results obtained. The

TABLE I.—*Showing the effects of Alcohol and of Brandy and Whisky on Salivary Digestion.*

10 c.c. standard starch mucilage + varying quantities of proof Spirit, brandy or whisky + water up to 100 c.c. + 1 c.c. of filtered saliva.

Proportion of Proof Spirit, Brandy, or Whisky in the Digesting Mixture	Time in which the achromic point was reached (Normal, 4 minutes)		
	Proof Spirit	French Brandy	Scotch Whisky
5 per cent. . .	4 minutes	4 minutes	4 minutes
10 ,, . .	4 ,,	very slow action	30 ,,
20 ,, . .	4 ,,	no action	very slow action
40 ,, . .	8 ,,	,,	no action
60 ,, . .	14 ,,	,,	,,
70 ,, . .	20 ,,	,,	,,
90 ,, . .	very slow action	,,	,,

indicated 'normal' of four minutes inserted at the head of the columns signifies that with simple water, without any foreign addition, the achromic point was reached in four minutes at blood heat. The first column shows the action of pure alcohol, merely diluted with water, and it is seen that the influence is extraordinarily slight. When the proportion of proof spirit amounts to 20 per cent., there is a slight precipitation of starch; this increases as the proportion of alcohol rises, until, with 90 per cent. proof spirit, there was almost total precipitation of starch. This precipitation evidently interferes with the activity of the ferment; but, even with 90 per cent. of proof spirit in the digesting mixture, there was some action, and sugar could be detected after a while in the mixture; gin gave approximately the same results as proof spirit. But brandy and Scotch whisky showed an inhibitory effect greatly out of proportion to the

quantity of alcohol contained in them; and brandy was sensibly worse than whisky. The cause of this discrepancy does not depend on the slight acidity of these spirits, for I obtained the same results when this was neutralised. It seems to be owing chiefly to certain ethereal bodies and volatile oils contained in them. In the case of brandy the retarding effect depends partly on a trace of tannin which that spirit always contains; and tannin, as we shall presently see, has an intense inhibitory effect on salivary action.

Looking at these results, it would not appear that ardent spirits, as used dietetically, hamper salivary digestion, but rather promote it by causing an increased flow of saliva. A tea-spoonful of brandy or whisky, introduced into the mouth, can be perceived at once to cause a gush of saliva. The common practice of adding a table-spoonful of brandy to a basin of arrowroot or sago gruel, therefore, promotes its digestion; but the proportion should not much exceed five per cent., and gin is evidently a preferable addition to brandy or whisky. Brandy and whisky precipitated the starch more readily than proof spirit or gin.

Wines.—Both the stronger and the lighter wines showed a powerful inhibitory effect on salivary digestion. Even so small a proportion as one per cent. of sherry or hock was found to paralyse saliva almost completely, and even one half or one quarter of this proportion delayed the achromic point appreciably. Claret and port wine behaved similarly. The inhibitory effect of wines is entirely due to the very considerable degree of acidity which they all possess. In the preparation of white wine whey we are in the habit, unconsciously, of utilising the acidity of sherry to break the hot milk—for, it is not the spirit contained in the wine, but its acid, that causes the milk

to curdle. When the acidity of wines is neutralised they lose entirely their inhibitory effect on salivary digestion.

TABLE II.—*Exhibits the results obtained with Sherry and Hock on Salivary Digestion.*

10 c.c. standard starch mucilage + varying quantities of sherry or hock + water up to 100 c.c. + 1 c.c. saliva.

Proportion of Sherry or Hock contained in the Digesting Mixture	Time in which the achromic point was reached (Normal, 4 minutes)	
	Sherry	Hock
0·25 per cent. . . .	8 minutes	16 minutes
0·5 ,, . . .	30 ,,	80 ,,
1· ,, . . .	no action beyond soluble starch	no action beyond soluble starch
2· ,, . . .	no action	no action
40· ,, neutralised	4 minutes	4 minutes

Action of Acids on Salivary Digestion.—This is a question of considerable interest—not only because we are in the habit of using acid wines and malt liquors with our food, but also vinegar and pickles, lemon juice, and puddings or pies containing acid fruits or acid rhubarb stalks.

The annexed table shows the effect of table vinegar on salivary digestion :—

TABLE III.—*Effect of Table Vinegar on Salivary Digestion.*

10 c.c. standard starch mucilage + varying quantities of vinegar + water up to 100 c.c. + 1 c.c. filtered saliva.

Proportion of Vinegar contained in the Digesting Mixture	Time in which the achromic point was reached (Normal, 4 minutes)
0·02 per cent. = 1 in 5000 . .	6 minutes
0·05 ,, = 1 in 2000 . .	14 ,,
0·1 ,, = 1 in 1000 . .	30 ,,
0·2 ,, = 1 in 500 . .	no action

The table shows that the hindering effect of vinegar is very powerful. Even so small a proportion as 1 in 5,000 sensibly delayed the action; with a proportion of 1 in 1,000 the action was very slow, and it was altogether arrested when the proportion of vinegar rose to 1 in 500.

The bearing of these results on the use of salads is evident. Salads are usually highly seasoned with vinegar, and they are commonly eaten with a liberal use of bread. The acid may perhaps assist in the digestion of the salad; but it is obvious that it would altogether prevent any salivary action on the bread eaten with it. This, of course, is a matter of no moment to a eupeptic individual, who has abundant digestive resources; but those of weak digestion would do well to be sparing in the use of acid salads and other sour dishes.

Malt Liquors.—Malt liquors were found to hamper salivary digestion exactly in proportion to their degree of acidity. Sound English beers have not nearly so much acidity as wines—and they interfere comparatively little with the digestion of starch; but 'turned' beer is highly inhibitory.

Effervescent Table Waters.—The examination of these yielded some odd results. A pure aerated water, charged merely with carbonic acid, exhibited considerable inhibitory power on salivary action. When the digesting mixture contained fifty per cent. of a carbonated water, the diastasic action was wholly arrested, and even so small a proportion as ten per cent. postponed the achromic point from four to thirty minutes. But the effervescent table waters of commerce—soda water, potash water, seltzer water, Apollinaris water, &c.—are all more or less charged with alkaline carbonates; and this charge of alkali altogether removes their inhibitory effect on salivary digestion.

These waters are, as you know, extensively used both here, and still more on the Continent of Europe, as an addition to wines—to claret, hock, and sherry, especially. And the effect of this addition is to greatly mitigate, or wholly to obviate the retarding influence of these wines on the digestion of starch. The use of these waters as an addition to wines is, therefore, highly commendable.

TEA, COFFEE, AND COCOA.

The effect of tea and coffee on salivary digestion presented a strong contrast, for while tea exhibited an intense inhibitory action, coffee—and with it may be ranged cocoa—had only a subordinate effect. As this is the first time I have had occasion to speak of experimental inquiries into the effect of these beverages I must enter into a little explanation. There is no standard strength of tea and coffee, but from information gathered in the social circle, and observations on the beverages put on my own table, I have learnt that the medium strength of tea is from four to five per cent., that is, four or five parts by weight of the dry leaf to a hundred parts of boiling water. Strong tea runs up to about seven per cent., and weak tea goes down to two per cent. Coffee is generally used in a stronger infusion than tea. Medium coffee has a strength of about seven per cent., and strong coffee—the black coffee or 'Café noir' of our French neighbours—has a strength of about twelve or fifteen per cent. Cocoa, on the other hand, is usually made weak; the printed directions given on the packets of cocoa indicate a strength of only about two per cent. This is probably one of the reasons why cocoa has a higher reputation as an aid to digestion than tea or coffee.

TABLE IV.—*Effect of Tea and Coffee on Salivary Digestion.*

10 c.c. standard starch mucilage + varying quantities of tea and coffee (both of 5 per cent. strength) + water to 100 c.c. + 1 c.c. filtered saliva. Both beverages were infused for ten minutes and then filtered.

Proportion of Tea or Coffee contained in the Digesting Mixture	Time in which the achromic point was reached (Normal, 4 minutes)	
	Tea—5 per cent. strength	Coffee—5 per cent. strength
1 per cent.	8 minutes	4 minutes
2 ,,	30 ,,	4 ,,
3 ,,	50 ,,	4 ,,
5 ,,	180 ,,	4 ,,
10 ,,	no action beyond soluble starch	4 ,,
20 ,,	no action	4 ,,
40 ,,	— —	10 ,,
60 ,,	— —	20 ,,

Tea.—The table shows that tea is a powerful retarder of salivary digestion. When the digesting mixture contained even so small a proportion as one per cent. there was a perceptible retardation, and as the proportion increased the inhibitory effect was rapidly intensified. With a proportion of two and three per cent. the achromic point was delayed from the normal of four minutes to thirty and fifty minutes respectively; with five per cent. it was delayed to three hours, and above this proportion there was practically no digestion of starch. A specimen of high-class Assam tea was found to retard salivary digestion somewhat more powerfully than a good China tea. A very cheap low-class tea costing 1*s.* 6*d.* per lb., such as is supplied to the poorest classes, had very little retarding effect. It was probably an adulterated article.

What is the cause of the inhibitory action of tea on salivary digestion? It seems to be entirely due to the large proportion of tannin contained in tea. Black

China tea contains, according to the analyses of Jauke, an average of eight per cent. of tannin,[1] and, as the following table shows, tannin is highly inimical to the digestion of starch.

TABLE V.—*Shows the effect of Tannin on Salivary Digestion.*

10 c.c. standard starch mucilage + varying quantities of tannin + water to 100 c.c. + 1 c.c. filtered saliva.

Proportion of Tannin in the Digesting Mixture	Time in which the achromic point was reached (Normal, 4 minutes)
0·002 per cent. = 1 in 50,000 .	10 minutes
0·005 ,, = 1 in 20,000 .	40 ,,
0·01 ,, = 1 in 10,000 .	no digestion beyond soluble starch
0·02 ,, = 1 in 5,000 .	no digestion

On comparing the results obtained with tea and those obtained with tannin, and calculating the amount of tannin which would be contained in a five per cent. infusion of tea, the conclusion is arrived at that the tannin contained in tea fully accounts for its inhibitory effect on salivary digestion. For if the tea operated with contained eight per cent. of tannin and three-fourths of this were taken up in the infusion, it would yield a solution containing 0·3 per cent. of tannin, and the effect of such a percentage of tannin would correspond very exactly with the results shown by experiment to be produced by the tea employed. It appears that tannin exists in two conditions in the tea leaf. One, the larger, portion is in the free state, and is easily extracted by hot water; but about one-fourth is fixed and remains undissolved in the fully exhausted tea leaves. Some persons have supposed that by infusing tea for a very short time—only two or three minutes—the passing of tannin into the infusion could be avoided. This is

[1] Walter Blyth, *Foods, their Composition and Analysis*, p. 334.

a delusion; you can no more have tea without tannin than you can have wine without alcohol. Tannin, in the free state, is one of the most soluble substances known. If you pour hot water on a little heap of tannin it instantly dissolves like so much pounded sugar.

Tea-leaves when treated with hot water expand at once into thin broad laminæ, presenting a highly favourable condition for the rapid extraction of their soluble constituents. Tea infused for two minutes was not found sensibly inferior in its retarding power on salivary digestion to tea infused for thirty minutes. The deterioration of the flavour of tea by long infusion appears to depend on the slower taking up of a bitter principle, which is less soluble than tannin, and which, apparently, does not interfere with diastasic action. If you wish to minimise the inhibitory action of tea on starch digestion, you should direct, not that it be infused for two or three minutes, but that it should be made very weak and used very sparingly, and that it should be drank not with the meal but after the meal has been swallowed. There is a curious difference in the practice of different persons in the way in which they imbibe beverages with their meals. Some drink and eat at the same time, others eat first and drink afterwards. The latter are the wiser if it be an object to facilitate their salivary digestion.

There is another device by which the inhibitory effect of tea on salivary digestion may be obviated, and which may be recommended to persons of weak digestion. The introduction of a pinch of bicarbonate of soda into the teapot completely removes the deterrent effect of tea on starch digestion. This is a practice I have seen followed in some households, under the idea that the soda helps to extract the virtue of the tea. I found on experiment that the addition of so small a proportion as one per cent.

of bicarbonate of soda to the weight of the dry tea-leaf greatly mitigated the inhibitory effect of the infusion on starch digestion, and that twice this quantity (two per cent.) almost entirely removed it. This latter proportion corresponds roughly to about ten grains of soda (as much as will stand on a threepenny-piece) to an ounce of the dry tea-leaf. A darker coloured infusion is obtained thereby, but the flavour is not sensibly altered, nor is there an alkaline reaction produced—for tea-infusion, like most other vegetable infusions, is slightly acid to test paper; and the quantity of soda here mentioned is only just sufficient to neutralise that acidity. But is the inhibitory effect of tea on starch digestion injurious to healthy people? Is not this retarding effect really one of the objects which we unconsciously aim at in using this beverage? I will return to these questions later on when I come to consider the effects of our food-accessories on peptic digestion.

The peculiar alkaloid of tea—theine or caffein, for the two bodies are identical—and the volatile oil which gives it aroma, seem to have no part in the inhibitory effect of tea on digestion. I made direct experiments with citrate of caffein, and found it indifferent, at least in such proportions as it could ever be present in our tea infusions. I tested the effect of theine and the volatile oil in another way. I sprinkled some dry tea-leaf on a plate and exposed it for four hours to a temperature of 212° Fahr. (100° C.). This would suffice to drive off both the alkaloid and the volatile oil. Tea so treated was found to have lost none of its inhibitory effects on starch digestion.

Coffee.—Coffee was found to have a far less inhibitory action on salivary digestion than tea (see Table IV.) Operating on a 5 per cent. infusion of a high-class coffee,

it was found that up to a proportion of twenty per cent. in the digesting mixture there was no appreciable retarding effect. With forty per cent. the achromic point was delayed from the normal of four minutes to ten minutes. Above this point the retarding effect increased somewhat; but even when the digesting mixture contained ninety per cent. of coffee digestion still went on with considerable speed. In coffee, tannin is replaced by a modification of that substance called caffeo-tannic acid, and this accounts for the marked difference in the effect of the two beverages on salivary digestion.

Cocoa resembles coffee in its effect on starch digestion, and it may be regarded as practically indifferent. We may therefore infer from these observations that the use of coffee and cocoa, in so far as concerns their influence on salivary action, is more to be recommended to persons of feeble digestion than the use of tea.

Beef-tea, Salt, and Sugar.—We shall see presently that both beef-tea and salt exercise a considerable effect on peptic digestion; it was therefore desirable to test their influence on salivary digestion. I found that neither beef-tea, nor salt, nor sugar, in any such proportions as they were likely to be used dietetically, had any effect on salivary action. Strong solutions of salt and sugar did not hinder, and very weak ones did not appreciably assist.

Such are the facts relating to salivary digestion revealed by experiment. I have indicated, in going along, the lessons to be learned from them. You will observe that none of the agents tried lent any assistance to the action of the ferment. Those that were not indifferent acted adversely. Tea and wines retarded the most powerfully.

The distilled spirits, coffee and cocoa, as used dietetically, may be pronounced to be indifferent. The mitigating effects of bicarbonate of soda on tea, and of the commercial table-waters on wines appear to be well worth bearing in mind.

LECTURE III.

EFFECT OF FOOD-ACCESSORIES ON PEPTIC DIGESTION.

SUMMARY:—Method of experimentation—Effect of varying quantities of hydrochloric acid—and of pepsin—Effect of alcohol and the distilled spirits—Port and sherry—Hock, claret, and champagne—Malt liquors—Effervescent table-waters—Tea and coffee—Beef-tea and whey—Sugar, salt, glycerine, and fruit-juices.

GENTLEMEN,—

THE full force of the accessory articles of food falls upon gastric digestion. Both the food and the accessories used therewith pass almost unaltered into the stomach, and sojourn there together for some length of time. Experiments *in vitro* on gastric digestion do not assimilate so closely to the natural function as is the case with experiments on salivary digestion. For, as digestion proceeds in the stomach, the conditions gradually vary and change; the acidity tends to increase in degree, the amount of pepsin also probably increases; the products of digestion are in part absorbed as the process goes on; there is also a rapid absorption in the stomach of saline matters and of such bodies as alcohol and ethereal compounds. With all this there is a much more perfect stirring up or churning of the gastric contents than can be effectuated in a glass tube or beaker. The results of experiment must therefore be interpreted with a certain allowance for these differences of conditions.

Method of Experimentation.—Seeing that the chief work of the stomach is to get the solid proteids of the

food into solution, or into a homogeneous magma or chyme, the most suitable objects for experiment on gastric digestion are the various meat and fish muscle-fibre, boiled white-of-egg, and bread. Meat-fibre was prepared by mincing lean beef, carefully freed from fat, and boiling it for fifteen minutes in two successive waters. The dry and hard-looking residual fibre, after copious washing with cold water and pressing through a cloth, was then pounded in a mortar, and spread out to dry at 100° C. When thoroughly dried, it was reduced to a powder and passed through a fine wire sieve. In this way a dry powder was obtained of very uniform character. Fish-fibre, from the cod, was prepared in exactly the same way, and yielded an admirable material for experiments on digestion. White-of-egg was prepared by peeling off the white of hard-boiled eggs and then pressing the material through a fine wire sieve. By this device, long, thin, uniform cylinders of egg-albumen were obtained, very well adapted for the purpose in hand. Bread was prepared simply by drying completely at 100° C. and then reducing to a fine powder and passing through a sieve.

Most of the experiments were repeated with egg-albumen, beef-fibre and fish-fibre, but the larger number of trials were made with the beef-fibre; and in the tables which follow the results with beef-fibre are almost the only ones recorded; for it was found that no essential differences showed themselves in the effect of the several food-accessories on the digestion of these three preparations.

The general plan of the experiments was the following. Four or five large glass tubes *a*, *b*, *c*, *d*, and *e*, were each charged with two grams of dry meat- or fish-fibre (or ten grams of moist egg albumen). 100 c.c. of water, acidulated with hydrochloric acid to 0·15 or 0·2 per cent. HCl were then added to each tube. The

tubes were then set upright in a pan of warm water and maintained at blood-heat. Tube *a* was always the control tube, or 'normal' tube, and contained nothing but the material operated on, acidulated water, and pepsin. The remaining tubes *b*, *c*, *d*, and *e*, contained varying quantities of the liquid or substance the effect of which it was wished to test. This was always included in the dilution water—so that the digesting mixture always amounted to 100 c.c. When the meat- or fish-fibre had fully swelled out in the acid medium—that is to say, in about twenty minutes—there was added to each tube 2 c.c. of an active glycerine-extract of pepsin. The tubes were frequently and equally agitated as digestion proceeded. At the end of about thirty minutes, under these conditions, digestion was usually concluded in the control tube (tube *a*)—that is to say, nearly all the meat- or fish-fibre (or white-of-egg) had passed into solution. It could also be seen by the depth and density of the undissolved residue in the other tubes how digestion was going on in them. In the course of an hour, or two, or three, a fair judgment could be formed of the relative progress or speed of digestion in all the tubes. In recording the results, the time of completed digestion in the control tube (or 'normal') was always taken as 100 minutes—though the real time was often only about 30 minutes. This was done partly to facilitate comparison of the results in the several tubes, and partly in order to approximate more nearly to the usual duration of digestion in the living stomach. In most of the tables which follow, the results recorded are not the results of single experiments but the mean of several. They must accordingly be regarded not as precise, but as approximative, results.

For purposes which will appear later on, it was

considered desirable, in the first instance, to ascertain the effect on the speed of digestion, of varying quantities of hydrochloric acid—and of varying quantities of pepsin. The results of experiments on these points are recorded in Tables VI. and VII.

TABLE VI.—*Showing the effect of varying quantities of Hydrochloric Acid on the Speed of Peptic Digestion.*

2 grams beef-fibre + 1 c.c. glycerine-extract of pepsin + varying proportions of hydrochloric acid + water to 100 c.c.

Proportion of dry HCl in the Digesting Mixture	Time in which Digestion was completed
0·05 per cent.	500 minutes—almost no digestion
0·08 ,, ...	200 ,,
0·1 ,, ...	130 ,,
0·15 ,, ...	115 ,,
0·2 ,, ...	100 ,,
0·3 ,, ...	115 ,,
0·4 ,, ...	160 ,,
0·6 ,, ...	350 ,, embarrassed

You will observe that the highest speed of digestion was obtained with a proportion of acid amounting to 0·2 per cent. HCl. This accords with the results obtained long ago by other observers. There is, however, not much difference between any proportions of acid varying from 0·1 per cent. HCl to 0·3 per cent. HCl; but above and below these proportions of acid the speed of digestion rapidly declines. With a proportion below 0·08 per cent. HCl, or a proportion above 0·4 per cent. HCl, the time in which digestion is completed is more than trebled.

With varying quantities of pepsin and constant quantities of acid the relations are quite different, as the following table shows.

TABLE VII.—*Showing the effect of varying quantities of Pepsin on the Speed of Peptic Digestion.*

2 grams of dried fish fibre + 0·15 per cent. HCl + varying quantities of glycerine-extract of pepsin + water to 100 c.c.

Proportion of Extract of Pepsin in the Digesting Mixture	Time in which Digestion was completed
0·125 per cent.	300 minutes
0·25 ,, ...	260 ,,
0·5 ,, ...	200 ,,
1· ,, ...	140 ,,
2· ,, ...	100 ,,

It is seen that the speed of digestion is roughly proportionate to the amount of pepsin in the digesting mixture. The more pepsin, the greater is the speed of digestion; and the less pepsin, the slower is the speed of digestion—without any limit on either side. And we should probably see, as I formerly observed with diastase and starch digestion,[1] that if it were possible to arrange the experiment so as to eliminate all interfering conditions, the speed of peptic digestion would be found to be exactly proportional to the quantity of pepsin contained in the digesting mixture.

The observations of Richet[2] indicate that the degree of acidity of the contents of the stomach during digestion, although it varies through a considerable range, has a marked tendency to maintain a certain normal average (which he fixed at about 0·17 per cent. HCl); and that if either acid or alkali be added to the digesting mass, the mean is presently restored automatically—the stomach in the former case ceasing to secrete acid, and in the latter case secreting an increased quantity of acid.

[1] See paper by the author, *On the Estimation of the Amylolytic and Proteolytic Activity of Pancreatic Extracts.* Proceedings of the Royal Society, 1881, p. 148.

[2] *Du Suc Gastrique*, Paris, 1878.

I now proceed to lay before you the results of the experiments made to test the effect of the various food-accessories on the speed of peptic digestion—and first with regard to alcohol, and the various alcoholic beverages.

Proof Spirit, Brandy, Whisky, and Gin.—The results are thrown together into a single column, because the ardent spirits were found to affect peptic digestion simply in proportion to the quantity of alcohol contained in them.

TABLE VIII.—*Shows the effect of Proof Spirit, together with Brandy, Whisky, and Gin, on Peptic Digestion.*

2 grams of beef fibre + 0·15 per cent. HCl + 1 c.c. glycerine-extract of pepsin + varying proportions of proof spirit, brandy, whisky, or gin + water to 100 c.c.

Proportion of Proof Spirit, Brandy, Whisky, or Gin contained in the Digesting Mixture	Time in which Digestion was completed (Normal, 100 minutes)
5 per cent.	100 minutes
10 ,,	115 ,,
20 ,,	135 ,,
30 ,,	180 ,,
40 ,,	300 ,, embarrassed
50 ,,	almost no digestion

It is quite surprising to observe how slight the effect of alcohol is on the chemical acts of digestion. Under ten per cent. of proof spirit, there was no appreciable retardation. With ten per cent., retardation was only barely detectable. With twenty per cent. there was quite distinct, but still only a slight, retardation. Above this point, however, the inhibitory effect of alcohol increased rapidly—it was considerable with thirty per cent. of proof spirit—with forty per cent. digestion was evidently embarrassed, and with fifty per cent. the ferment was almost paralysed. Considering the quantity of brandy,

whisky, or gin commonly used dietetically with meals, it is evident that the amount is not sufficient to appreciably retard the speed of gastric digestion. For if the digesting mass in the stomach be estimated at 2 lbs., a wine-glass (2 oz.) of brandy or whisky added thereto would only equal five per cent. of proof spirit, and this, as the table shows, is too small a proportion to hamper digestion. Even double this amount would scarcely have an appreciable effect. These spirits therefore impede digestion only when taken immoderately, and in intoxicating quantities. Moreover, alcohol is rapidly absorbed by the coats of the stomach, and its proportion in the digesting mass would be speedily reduced. These experiments therefore indicate that ardent spirits, as usually employed dietetically by temperate persons, act as pure stimulants to gastric digestion, causing an increased flow of gastric juice,[1] and stimulating the muscular contractions of the viscus, and so accelerating the speed of the digestive process in the stomach.

The less concentrated kinds of alcoholic beverages, wine and beers, have an effect on peptic action which differs importantly from that of the distilled spirits. Their inhibitory influence is greatly out of proportion to the dosage of alcohol contained in them. It is desirable to distinguish between the effects of the stronger wines (port and sherry), and of the lighter wines (clarets, hocks, and champagnes), and of malt liquors.

Sherry and Port Wines.—The sherry used was a full-bodied mature wine of the dessert class. The results were controlled by experiments with a light dinner sherry, and no great difference was found between them. The

[1] We may assume that alcohol would act in this respect in the same way as it acts on the salivary secretion.

port used was over thirty years old, well matured and of a fine but light quality.

TABLE IX.—*Showing the effect of Sherry and Port on Peptic Digestion.*

2 grams of beef-fibre + 0·15 per cent. HCl + 1 c.c. glycerine-extract of pepsin + varying quantities of sherry and port + water to 100 c.c.

Proportion of Sherry or Port contained in the Digesting Mixture	Time in which Digestion was completed (Normal, 100 minutes)	
	Sherry	Port
5 per cent. . . .	115 minutes	100 minutes
10 ,, . . .	150 ,,	115 ,,
15 ,, . . .	200 ,,	150 ,,
20 ,, . . .	300 ,, embssd.	180 ,,
30 ,, . . .	almost no digestion	200 ,,
40 ,, . . .	— —	embarrassed

It is evident that the retarding effects of sherry and port considerably exceed what is due to the alcohol contained in them. The table shows that when the digesting mixture contained 40 per cent. of either wine, the action of the ferment was almost brought to a standstill. These wines are estimated to contain about 20 per cent. of absolute alcohol (or 40 per cent. of proof spirit); therefore, 40 per cent. of these wines is only equivalent in alcoholic strength to 16 per cent. of proof spirit—and this proportion of alcohol, as may be seen by Table VIII., retards digestion only slightly. Even in the proportion of 20 per cent., sherry trebled the time in which digestion was completed. There must therefore be in these wines some retarding agent besides alcohol. I shall return to this subject later on.

As used dietetically, sherry must figure as having frequently an important retarding effect on peptic digestion. This wine is used with dinner by some persons very freely. Half-a-pint of sherry is no unusual allow-

ance; and this, in a total gastric charge of two pounds, amounts to about 25 per cent., which the table shows to be a highly inhibitory proportion. In the more common practice of taking two or three wine-glasses of sherry with dinner, we see probably a double action—a stimulating action on the secretion of gastric juice, and on the muscular contractions of the stomach, and a slight retarding effect on the speed of the chemical process, especially in its early stages. In smaller proportions, a wine-glass or so, sherry would act as a pure stimulant to digestion. In connection with the dietetic use of sherry it should be further remembered that it exercises a strong inhibitory effect on the salivary digestion of bread and other farinaceous articles.

Hock, Claret, and Champagne.—The hock and claret (Bordeaux) used were of medium quality; the champagne was Moet & Chandon's 'extra superior.'

TABLE X.—*Shows the effect of Hock, Claret, and Champagne on Peptic Digestion.*

2 grams of dried beef-fibre + 0·15 per cent. HCl + 1 c.c. glycerine-extract of pepsin + varying proportions of hock, claret, or champagne + water to 100 c.c.

Proportion of Hock, Claret or Champagne in the Digesting Mixture	Time in which Digestion was completed (Normal 100 minutes)		
	Hock	Claret	Champagne
10 per cent. . .	100 minutes	100 minutes	90 minutes
20 ,, . . .	115 ,,	140 ,,	100 ,,
40 ,, . . .	150 ,,	180 ,,	130 ,,
60 ,, . . .	Embarrassed	Embarrassed	180 ,,

We observe again that the retarding effect of these wines is out of proportion to the alcohol contained in them. These wines are estimated to contain from 10 to 12 per cent. of absolute alcohol (20 to 24 per cent. of proof spirit), so that, however freely they might be used

dietetically, the amount of alcohol so introduced, even if they were used up to 80 per cent. of the total contents of the stomach, would scarcely produce an appreciable effect on peptic action. We must, therefore, again here recognise the presence of some other retarding agent besides alcohol. The table shows that champagne has a markedly less retarding effect than hock and claret. Indeed, in the proportion of 10 per cent., champagne had a distinct, though slight, accelerating effect. This superiority of champagne is due probably, as we shall presently see reason to believe, to the mechanical effects of its effervescent qualities.

If we consider the copious proportions in which hock and claret are used dietetically, it becomes evident that their retarding effect on peptic digestion is often brought into play. A pint of claret or hock is a common allowance with dinner for robust eaters—and such a proportion, as the table shows, would not be without considerable effect. When French and Italian peasants use freely, as they do, a wine akin to claret with their meals, which are mainly composed of bread and other farinacea, the effect must be highly retardive on digestion.

On the other hand, the more sparing use of these wines, a glass or two, with dinner or luncheon would evidently not produce any appreciable retardation of peptic action, but would, like corresponding doses of sherry, act as pure stimulants. In both these instances, as in some others, it seems to be indicated that by adjusting the quantities we may elicit diverse effects. With large quantities we may obtain retardation, with small quantities we may obtain acceleration of gastric digestion.

Malt Liquors.—The malt liquors experimented on were bottled Burton ale, a light sparkling English table beer, and Lager beer.

TABLE XI.—*Shows the effect of Malt Liquors on Gastric Digestion.*

2 grams of dried beef-fibre + 0·15 HCl + 1 c.c. glycerine-extract of pepsin + varying quantities of malt liquors + water to 100 c.c.

Proportion of Malt Liquors contained in the Digesting Mixture	Time in which Digestion was completed (Normal, 100 minutes)		
	Burton ale	Light English table beer	Lager beer
10 per cent. . .	115 minutes	100 minutes	100 minutes
20 ,, . . .	140 ,,	115 ,,	115 ,,
40 ,, . . .	200 ,,	140 ,,	140 ,,
60 ,, . . .	Embarrassed	180 ,,	180 ,,

The retarding effect of malt liquors is (as is the case with wines) altogether out of proportion to their percentage of alcohol. These beverages contain only from 4 to 6 per cent. of alcohol (8 to 12 per cent. of proof spirit), so that the alcohol contained in them could scarcely ever, on its own account, produce any effect. Their retarding influence must, however, often come into operation. These beverages are used very freely with meals, and the digesting mass in the stomach must often contain them in the proportion of 50 or 60 or sometimes even 80 per cent. Such proportions would act as powerful retardants, especially on the digestion of bread and other articles of farinaceous food. In more moderate quantities—a tumbler or so—especially of the lighter beers, this effect would evidently be more promotive than retardive of gastric digestion. It was found experimentally that beer when 'well up' was distinctly more favourable to quick digestion than the same beer when 'flat.'

Effervescent Table Waters.—Simple carbonated water distinctly hastened peptic digestion; but the favourable effect was quite subordinate—and it was better brought out with proportions of 10, 20, and 40 per cent., than

with larger proportions. I attributed the slight acceleration observed entirely to the mechanical operation of the escaping gas, in causing an additional stirring up of the digesting mixture. The ordinary commercial effervescent table waters—soda- and potash-water, seltzer and Apollinaris waters—all contain, as before stated, a certain quantity of an alkaline carbonate. This would have necessarily a certain neutralising effect on the acid of the gastric juice. But I was surprised to find, even in a laboratory experiment, wherein, of course, there could not be, as would be the case in the living stomach, any compensating secretion of fresh acid, that these waters had, even in the proportion of 90 per cent., only a very slight and insignificant deterrent effect on peptic digestion. In smaller proportions their action was quite inappreciable. It may be inferred from these observations that the sparkling wines (as indeed was found experimentally to be the case with champagne) are less hindering to digestion than the still wines; and that, when used in moderate proportions, they may act, not only as stimulants to the secretion of gastric juice, and to the muscular activity of the viscus, but may, at the same time, slightly accelerate the speed of the chemical process in the stomach.

Tea and Coffee.—The effect of these important beverages is of great interest, in view of their wide diffusion and universal use. A large number of observations were made with the object of testing their influence on peptic digestion. The mean results are indicated in the following table.

TABLE XII.—*Shows the effects of Tea and Coffee on Gastric Digestion.*

2 grams of dried beef-fibre + 0·15 HCl + 1 c.c. glycerine-extract of pepsin + varying proportions of tea and coffee + water to 100 c.c.

Proportion of Tea or Coffee contained in the Digesting Mixture	Time in which Digestion was completed (Normal, 100 minutes)		
	Tea—5 per cent. strength	Coffee—5 per cent. strength	Coffee—15 per cent. strength
10 per cent. . .	105 minutes	105 minutes	160 minutes
20 ,, . . .	140 ,,	140 ,,	Embarrassed
40 ,, . . .	180 ,,	180 ,,	Almost no action
60 ,, . . .	Embarrassed	Embarrassed	

It is seen that both tea and coffee exercise a powerful retarding effect on peptic digestion. With infusions of equal strength there was no appreciable difference between the two beverages; but inasmuch as coffee is usually made of greater strength than tea, its effect as dietetically used is more potent. Cocoa was found, with infusions of equal strength, to possess nearly as much retarding effect as tea or coffee; but as it is usually made with a strength of only about 2 per cent., its inhibitory effect scarcely comes into play in the customary use of this beverage. Strong coffee, the 'café noir' of France, is seen to have a very powerful inhibitory effect. Even so small a proportion as 10 per cent. of this strong coffee in the digesting mixture abated the speed of digestion very considerably, and with 20 per cent. digestion was greatly embarrassed. Considering the copious proportions in which we use tea and coffee with our meals, it is obvious that the retarding effect of these beverages is commonly brought into operation in gastric digestion. I could not detect any appreciable difference between the effect of tea infused for 2 or 3 minutes and tea infused for 15 or 30 minutes. If you wish to minimise the retarding effects of tea, in persons of weak

digestion, you should give instructions that the beverage be made weak, or that it be used in sparing quantities.[1]

The effect of tea on gastric digestion is enhanced, in regard to bread and other farinaceous articles, by its powerful inhibitory action on salivary digestion; so that, speaking of these two phases of digestion together, tea must rank much higher as a retarding agent than coffee and cocoa. In the case of alcoholic beverages, their stimulating influence on secretion, and on the muscular activity of the stomach, operates as a partial set-off against their retarding effect on the chemical process of peptic digestion; but in the case of tea and coffee there is not, so far as is known, a corresponding compensation. Tea and coffee are probably pure retarders of the digestive process in the stomach; and the question will presently arise as to whether this is an evil or a good.

Beef-Tea and Whey.—Beef tea may be regarded as the representative type of the various soups and broths which are so largely used as accessories to the more solid ingredients of our food. And the unexpected effects of

[1] A good deal has been said of the injurious effects on gastric digestion of the tannin contained in tea. I question whether the statements made with reference to this matter are worthy of attention. It has been alleged that meat fibre is hardened by tea; and that the coats of the stomach are liable to be injured by this beverage. These views are entirely theoretical. Leather is no doubt a very tough indigestible substance, but meat fibre is not gelatine, and the coats of the living stomach are not dead membrane. Meat fibre does not, as a matter of fact, harden in tea; on the contrary, it swells nearly as freely in acidulated tea, of medium strength, as in simple acidulated water. And the same is true of a half per cent. solution of pure tannin. The effect of tannin on peptic action is comparatively slight; and its presence in tea only partially accounts for the inhibitory power of tea on the digestion of proteids in the stomach. The acid reaction of the gastric contents importantly modifies the reaction of tannin on albuminoid solutions, and largely obviates the precipitation of proteids which is occasioned by it in neutral media.

beef-tea on peptic digestion led to an examination of the effects of whey, and of infusions or decoctions of other articles of food—bread and fruit, and also of fruit juices. The results obtained with beef-tea and whey are chronicled in the following table. The beef-tea was made by gently boiling or simmering lean minced beef with an equal weight of water for thirty minutes, and filtering. The whey was made by coagulating warm milk with the peptic extract and then straining and filtering.

TABLE XIII.—*Shows the effect of Beef-tea and Whey on Peptic Digestion.*

2 grams of dried beef-fibre+0·15 HCl+1 c.c. glycerine-extract of pepsin + varying quantities of beef-tea or whey + water to 100 c.c.

Proportion of Beef-tea or Whey in the Digesting Mixture	Time in which Digestion was completed (Normal, 100 minutes)	
	Beef-tea	Whey
10 per cent. . .	115 minutes	105 minutes
20 ,, . . .	140 ,,	130 ,,
40 ,, . . .	Embarrassed	150 ,,
60 ,, . . .	Almost no digestion	Embarrassed

It is seen from the table that beef-tea has a powerfully retarding effect on peptic digestion—about equal to that of a five-per-cent. tea. Whey retarded sensibly less—about equal to hock.

With the single and trifling exception of aerated (carbonated) water, I found that none of the various accessories which we use with food aided peptic digestion. The most favourable conditions for rapid digestion were supplied with hydrochloric acid, pepsin, and simple water. Even minimal quantities of alcohol, wines, tea, or coffee did not give the least assistance to the chemical process. Some of the things I tried were found to be indifferent, or their retarding effect was so slight that in the quantities in which they are generally used dieteti-

cally the retardation could not be regarded as having any practical importance. Among these were cane sugar up to a proportion of 10 per cent., glycerine up to the same proportion, strong decoctions of bread, ripe apple, and pear, and the expressed juice of the grape and the orange. In regard to the two last, however, it was found that when their proportion in the digesting mixture amounted to 50 per cent. or over, a very considerable retardation occurred: grape juice had a more potent effect than orange juice. So large a proportion as 50 per cent. of these juices could, however, only occur in the gastric contents when these fruits were taken immoderately, as sometimes happens with children.[1]

[1] Dr. W. J. Fraser has published, in vol. xviii. of the *Journal of Anatomy and Physiology*, a very interesting paper—based on a large number of elaborate experiments—dealing with the effects of tea, coffee, and cocoa on peptic digestion. The results obtained by Dr. Fraser coincided generally with those recorded above; he found that these beverages in nearly every instance retarded peptic digestion. The plan of the experiments differed so widely from that followed by myself that it was not found possible to bring the results of the two sets of experiments into useful comparison.

LECTURE IV.

EFFECT OF FOOD-ACCESSORIES ON PEPTIC DIGESTION CONTINUED—THEIR EFFECT ON PANCREATIC DIGESTION.

SUMMARY:—Causes of the retarding effects of food-accessories on peptic digestion—In the cases of beef-tea and whey—Action of salts of the organic acids—and of chlorides of potassium and sodium—Effect of superacidulation and dialysis in removing the retarding effects of food-accessories—Retardation of peptic digestion probably beneficial in purpose—Argument on this question.

Effect of food-accessories on pancreatic digestion—On pancreatic diastase—On tryptic digestion—Clinical relations of gastric and pancreatic digestion in regard to the feeding of the sick.

GENTLEMEN,—

THE general results of the experiments described in the preceding lecture appeared to me not a little remarkable. I was particularly surprised to find that beef-tea and whey, which, as meat-juice and milk, are common articles of food, and which are given to invalids, should rank with alcohol, wines, tea, and coffee—and even, in the case of beef-tea, rank high—as retarders of peptic digestion. And nothing struck me more than the comparative feebleness of alcohol in this respect. Proof spirit, whisky, and brandy had no more retarding effect than so much beef-tea, and we have previously seen that alcohol is still more feeble as a retarder of salivary digestion.

What is the cause of these retarding effects? On inquiring into this question, it was speedily seen that the cause was different in different cases. In the case

of proof spirit the cause must, of course, be due directly to the alcohol contained in it; and the same is true of whisky, brandy, and gin, in regard to which it was found that their retarding effect was proportional to the quantity of alcohol they contained. But in regard to wines and malt liquors, their percentage of alcohol did not account for nearly their full effect; and with tea, coffee, beef-tea, and whey, alcohol had, of course, no part in the retarding effect produced by them. These latter are all highly complex fluids, containing various ingredients of widely different nature. The wines, besides alcohol, contain ethereal compounds and saline and extractive matters; and malt liquors contain, in addition to a small dosage of alcohol, the extractive matters of hops, dextrines, and salines. Tea and coffee contain the alkaloid theine (or caffeine), an essential oil, salines, and a bitter principle. Tea contains a large percentage of tannin, and coffee a still larger percentage of caffeo-tannic acid. Beef-tea and whey are rich in organic salts and other saline matters, besides very complex extractives. It is not surprising therefore that inquiry into the causal agent of retardation should reveal profound differences in this respect.

I have by no means mastered this subject, but I have obtained a certain amount of light, which has both a positive and a negative bearing.

It will facilitate matters if I take first the cases of beef-tea and whey. I think I have made out in both these instances that their retarding effect on peptic digestion is due to the presence in them of salts of the organic acids and of neutral inorganic salts; namely, to the lactates and sarcolactates, and to the chlorides of potassium and sodium which they contain.

It has been shown by Berthelot that salts of the

organic acids are decomposed in the presence of the mineral acids, just as the carbonates are—with this difference only, that in the latter case the carbonic acid, being gaseous, escapes with effervescence, whereas in the former case the organic acids which are set free remain in the solution. Therefore, when lactate or tartrate of potash is mixed in solution with free hydrochloric acid, there is immediately formed chloride of potassium, and free lactic or tartaric acid. And this is exactly what occurs in the stomach with beef-tea and whey, for the hydrochloric acid of the gastric juice seizes on the bases of the lactates and sarcolactates contained in these liquids, forming therewith chlorides of sodium and potassium, and setting free the organic acids; and although the acidity of the gastric contents is not thereby diminished, this acidity no longer consists of hydrochloric acid, but partly of that and partly of lactic acid: and if the quantity of beef-tea be considerable, all the hydrochloric acid may disappear, and only lactic acid be left free in the solution. The effect of this substitution is immense, for the organic acids have only a very feeble digestive power as compared with hydrochloric acid. On comparing experimentally lactic and tartaric acids with hydrochloric acid, I estimated that for equal saturating power the organic acids had not more than one-eighth or one-tenth of the digestive power of the mineral acid.

In order to test the actual effect of an organic salt on peptic digestion I made some observations with the neutral tartrate of potash. Varying quantities of this salt were added to the usual digesting mixture. The following table exhibits the results obtained:—

TABLE XIV.—*Showing the effects of Salts of the Organic Acids on Peptic Digestion—Neutral Tartrate of Potash.*

10 grams moist egg-albumen + 0·2 HCl +2 c.c. glycerine-extract of pepsin + varying quantities of neutral tartrate of potash + water to 100 c.c.

Proportion of Tartrate of Potash in the Digesting Mixture	Time in which Digestion was completed (Normal, 100 minutes)
0·05 per cent. = 1 in 2000 . .	115 minutes
0·125 ,, = 1 in 800 . .	160 ,,
0·25 ,, = 1 in 400 . .	Embarrassed
0·5 ,, = 1 in 200 . .	Almost no digestion

It is seen from the table that even so small a proportion of the tartrate as 1 in 2,000 retards digestion appreciably, and that one in 800 retards it considerably. To obtain an idea of the effect of this in the living stomach, let us suppose that the total gastric contents during digestion amounted to two pounds (14,000 grains), then so small a quantity as seven grains of the tartrate of potash would slightly prolong digestion, and eighteen grains would retard it considerably.

But the mere substitution of the organic for the mineral acid is not all—the presence of the newly formed chlorides in the digesting mixture is an additional cause of embarrassment to the digestive process. The annexed table exhibits the effects of the chlorides of sodium and potassium on peptic digestion.

TABLE XV.—*Showing the effects of Sodium and Potassium Chlorides on Peptic Digestion.*

10 grams moist egg-albumen + 0·2 HCl + 2 c.c. glycerine-extract of pepsin + varying quantities of sodium and potassium chlorides + water to 100 c.c.

Proportion of NaCl or KCl in the Digesting Mixture	Time in which Digestion was completed (Normal, 100 minutes)	
	Sodium Chloride	Potassium Chloride
0·1 per cent. = 1 in 1000	115 minutes	108 minutes
0·25 ,, = 1 in 400	150 ,,	130 ,,
0·5 ,, = 1 in 200	Embarrassed	150 ,,
1· ,, = 1 in 100	Almost no digestion	Embarrassed

The table shows that sodium chloride has a very considerable power of retarding peptic action. Even in the proportion of 1 in 1,000, it has an appreciable effect; and with 0·5 per cent. (or 1 in 200) the effect is so great as almost to bring the process to a standstill; the potassium salt has very distinctly less retarding effect, as the table indicates, than the soda salt.[1]

These observations yield presumptive evidence that the lactates and neutral mineral salts known to exist in beef-tea are the real retarding agents of that liquid, and that probably kindred salts contained in whey, beer, and wines may account, at least in part, for the retarding effects of these beverages.

Now, if this explanation be correct, we ought to find that by increasing the hydrochloric acid in a digesting mixture containing beef-tea the retarding effect is mitigated. For if the lactates of beef-tea cause occultation of a portion of the free mineral acid, and thereby retard the speed of digestion, we should expect to find that the addition of more of the mineral acid, so as to compensate for this loss, would partly obviate the retarding effect; and this is precisely what occurred on experiment. The effect of *superacidulation* was tested not only with beef-tea, but also with whey, coffee, tea, wines, and malt liquors. The results obtained, however, only fully answered expectations in the cases of beef-tea and whey.

[1] The powerful inhibitory effect of sodium chloride on peptic digestion has probably some bearing on the old debated question of why the stomach does not digest itself. The blood-serum contains just 0·5 per cent. of sodium chloride, and this proportion is seen by the table to inhibit peptic digestion. No doubt, as Dr. Pavy pointed out, the principal obstacle to the self-digestion of the stomach during life is the alkaline reaction of the blood-serum; but the presence in it of the sodium chloride is an additional and very interesting security against such a disaster.

In regard to the other beverages the results were either *nil* or very slight. The observations tabulated in Table VIII., page 40, indicate that the rate of digestion of beef-fibre is sensibly the same with an acidulation of 0·15 per cent. HCl and with an acidulation of 0·3 per cent. HCl. Accordingly comparison was made with these two grades of acidulation in digesting mixtures containing an inhibitory proportion (that is to say, a proportion which would approximately treble the normal time of digestion) of beef-tea, whey, coffee, tea, wines, or malt liquors. The results obtained are chronicled in the following table:—

TABLE XVI.—*Showing the effect of Superacidulation on Digesting Mixtures containing Inhibitory Quantities of various Beverages.*

2 grams of dried beef-fibre + 2 c.c. peptic extract + inhibitory quantities of beef-tea, whey, tea, coffee, wine, or malt liquor + water to 100 c.c.

Addition to the Digesting Mixture		Time in which Digestion was completed (Normal, 100 minutes)	
		0·15 per cent. HCl	0·3 per cent. HCl
Beef-tea	40 per cent.	300 minutes	120 minutes
Whey	50 ,,	300 ,,	130 ,,
Coffee	50 ,,	300 ,,	200 ,,
Tea	50 ,,	300 ,,	240 ,,
Claret	50 ,,	300 ,,	300 ,,
Hock	50 ,,	300 ,,	300 ,,
Burton ale	50 ,,	300 ,,	300 ,,
Sherry	20 ,,	300 ,,	330 ,,
Port	30 ,,	300 ,,	330 ,,

It is seen that with beef-tea superacidulation acted powerfully in obviating the retarding effect—in fact, almost nullifying it altogether. With whey the increased acidity also acted powerfully in the same direction—not nearly so much, but still considerably, with coffee—much less with tea—and not at all with the lighter wines and Burton ale. With sherry and port superacidula-

tion distinctly aggravated the inhibitory effect of these beverages.[1]

The conclusion was therefore arrived at that the inhibitory effects of beef-tea and whey were largely due to the salts of the organic acids contained in them, that the same explanation applied only partially to the effects of coffee, and still less with regard to tea. In the case of wines and malt liquors, it was evident that their inhibitory effects must be otherwise accounted for.

Further light on the retarding effects of these several food-accessories was sought by subjecting them to dialysis, whereby a rude and imperfect but suggestive idea could be obtained of the effect on them of absorption through the walls of the stomach. In each case 100 c.c. of the liquid to be tested were dialysed for six hours into 3,000 c.c. of water; and the retarding effect of the dialysed product was compared with that of its undialysed counterpart. The results are recorded in the following table :—

TABLE XVII.—*Showing the effects of Dialysis.*[2]

2 grams dried beef-fibre + 0·15 HCl + 2 c.c. peptic extract + varying quantities of dialysed and undialysed beef-tea, whey, coffee, tea, light wines, or Burton ale + water to 100 c.c.

Addition to the Digesting Mixture		Time in which Digestion was completed (Normal, 100 minutes)	
		Undialysed	Dialysed for 6 hours
Beef-tea	40 per cent.	300 minutes	120 minutes
Whey	50 ,,	300 ,,	135 ,,
Coffee	50 ,,	300 ,,	210 ,,
Tea	50 ,,	300 ,,	240 ,,
Claret	50 ,,	300 ,,	210 ,,
Hock	50 ,,	300 ,,	210 ,,
Burton ale	50 ,,	300 ,,	195 ,,

[1] I take this to be due to the large proportion of alcohol contained in sherry and port; for I found that with proof spirit also superacidulation acted adversely on the speed of peptic digestion.

[2] The increase of the product in the dialyser varied a good deal. In

The results of dialysis, as shown in the above table, yield the same indications as superacidulation, and lead to the conclusion that in regard to beef-tea and whey the retarding agents are the crystalloids contained in these liquids, and which dialyse with rapidity. Coffee and ale were also considerably affected by dialysis, but tea and the light wines were only slightly affected by dialysis for six hours. I found that by dialysis for twenty-four hours the retarding power of all these beverages was almost entirely removed.

From these observations on superacidulation and dialysis it was inferred that with beef-tea and whey the saline matters contained in them are wholly answerable for their retarding effect on peptic digestion. With regard to coffee the retarding effect is partially due to saline matters, perhaps chiefly to the caffeo-tannate of potash contained in that beverage. In the case of ale it would also seem that the saline ingredients contained therein account for a considerable portion of its retarding effect; and it would further appear, from a comparison of the effects of superacidulation on the one hand, and dialysis on the other, that the retarding salines of ale are not salts of the organic acids, but neutral mineral salts—probably chlorides and phosphates of potash and soda.

In the cases of tea and coffee there arose the question whether the alkaloid, theine or caffeine, contained in these beverages contributed anything to their retarding effect on peptic digestion. Direct experiments gave a negative answer to this question. It was found that

the case of beef-tea, whey, the wines, and beer the increase amounted to about 10 per cent.; in the case of coffee to 4 per cent.; and in the case of tea to only 1 per cent. Allowance was made in the experiments for these differences.

citrate of caffeine, up to a proportion of 1 per cent. in the digesting mixture, had no appreciable effect—and this is a far larger proportion of the alkaloid than ever gets into solution in our ordinary infusions. Neither has the volatile oil contained in tea and coffee any effect. Tea and coffee which had been heated on a plate at 100° C. for a period of four hours—whereby both the volatile oil and the alkaloid would be driven off—yielded infusions which had not appreciably lost any of their retarding effects. The tannin of tea accounts for a portion of the retarding power of this beverage, but only for a portion. I found experimentally that the tannin contained in tea accounted for about one-half of the retarding effect of that beverage on peptic digestion.

With regard to wines, I am unable to account for their retarding effect on peptic digestion. Neither super-acidulation nor dialysis gave support to the idea that it was due to their saline ingredients. The retardation caused by these beverages was wholly out of proportion to the alcohol contained in them. In the case of sherry it was found that when this wine was briskly boiled for five minutes, and the loss by evaporation afterwards made up by the addition of water, its inhibitory effect was lessened by fully one-half. This showed that the high retarding power of sherry was largely due to its volatile constituents.

Speaking generally, we may infer that the retarding effects of beef-tea and whey are due to conditions which are easily obviated in the living stomach—either by the rapid absorption of their saline ingredients by the gastric capillaries, or by an increased secretion of gastric acid. But in regard to coffee, tea, the wines, and malt liquors, their retarding agency would appear to be less easily removable, and would therefore exercise a more persistent

influence on gastric digestion. The retarding power of beef-tea and whey is, however, worth bearing in mind: it accounts perhaps for the difficulty and discomfort which some persons notoriously experience in the digestion of soups and milk; and points to the desirability of restricting the amount of these fluids in persons of weak digestion. The practice of taking soup at the beginning of dinner is so widespread that it must be credited with some beneficial purpose. The object of the practice probably is to awaken the stomach to its work. Taken on an empty stomach the salines of the soup would be rapidly absorbed, and in passing through the coats of the stomach they would provoke both the glandular and the muscular activity of the organ. Taken in due quantity this would probably be the only effect, but taken in large quantity soup would undoubtedly display its retarding power on the chemical act of peptic digestion; it should therefore be partaken of sparingly by persons of feeble digestion. This rule, I apprehend, accords perfectly with common experience.

I shall have occasion to explain further on why beef-tea and milk, notwithstanding their retarding effects on the chemistry of gastric digestion, are nevertheless often suitable aliments for sick persons.

I come now to a curious and interesting question. What is the meaning of all this retarding effect? Why should the practice be almost universal among civilised races of taking with their meals beverages which retard digestion? And, considering the copious libations[1] of tea, coffee, beer, or light wines which healthy persons associate with their meals, it is quite evident that an

[1] This, however, only applies to persons in health. These agents figure quite differently in the dietetic habits of invalids. They are either altogether omitted from their dietary or used sparingly, or very diluted.

important retardation of gastric digestion is thereby frequently produced.

Is this retardation wholly, or even at all, evil? Do we healthy people take tea, coffee, wines, or beer with our meals for some collateral good, and in spite of their untoward retarding effect on the chemistry of digestion, or is there really some good in this retardation itself? and do we unconsciously use these beverages partly for this very purpose of abating the speed of gastric action?

It requires perhaps some courage to set forth and to defend a proposition apparently so paradoxical as that men take these beverages in part with the unconscious purpose of retarding their digestion. This is, however, what I propose doing, and I am countenanced in this speculative course by some words of Darwin. 'False facts,' he says, 'are highly injurious to the progress of science, because they often endure long; but false views, if supported by some evidence, do little harm, because everyone takes a salutary pleasure in proving their falseness; and when this is done one path of error is closed and the true path is often at the same time opened.'[1] The view I am about to suggest concerning digestive retardation may be true or false, and must submit to the test of criticism; but the facts indicated by the experiments stand equally fast whether that view prove true or false.

It does not really require much ingenuity to show cause why retardation of gastric digestion may not be regarded in the healthy and strong as having a beneficial purpose.

We must bear in mind that among civilised races the preparation of food for the table is carried to a high degree. The cereal grains which are employed to make bread are first finely ground and sifted from the bran by

[1] *Descent of Man*, chap. xxi.

the miller; the flour is then subjected with the aid of moisture and artificial heat to a cooking process; the meats and fish we eat are boiled or roasted; the vegetables we use are carefully deprived of their coarser parts, and then are boiled: all this preliminary preparation and cooking renders our food highly digestible, and easy of attack by the digestive juices. But this is not, I apprehend, the sole object in view. The preliminary preparation and cooking not only renders our food more digestible, but makes it also more capable of being thoroughly exhausted of its nutritive qualities. These two objects are not quite the same. Even as it is, and with all this careful preparation, some waste occurs; and the fæces always contain considerable remnants of undigested food. But it is obvious that if food be rendered too easy of digestion there arises a risk that the meal will pass too quickly, and wastefully, into the blood, and on through the tissues into the excretory organs, and so out of the body, before it has been made fully and economically available for the sustenance of the slow nutritive processes. Moreover, a sudden irruption into the blood of large quantities of newly digested aliment would tend to disturb the chemical equilibrium of that fluid, and so interfere with the tranquil performance of its functions. It would also tend to produce hepatic and other congestions, to the general disadvantage and discomfort of the economy. A too rapid digestion and absorption of food may be compared to feeding a fire with straw instead of with slower burning coal. In the former case it would be necessary to feed often and often, and the process would be wasteful of the fuel; for the short-lived blaze would carry most of the heat up the chimney. To burn fuel economically, and to utilise the heat to the utmost, the fire must be damped down so as to ensure slow as well as complete

combustion. So with human digestion, our highly prepared and highly cooked food requires, in the healthy and vigorous, that the digestive fires should be damped down in order to ensure the economical use of food.

In the plan of the dietary of the civilised races, arrived at slowly as the result of an immense experience, we seem therefore to detect two apparently contradictory aims—namely, on the one hand, to render food by preparation and cooking as digestible as possible; and, on the other hand, to control the rate of digestion by the use of certain accessory articles with food. In reality these objects are not contradictory but co-operative to a beneficial end. For, to express the problem in another way, it may be said that we render food by preparation as capable as possible of being completely exhausted of its nutrient properties; and, on the other hand, to prevent this nutrient matter from being wastefully hurried through the body we make use of agents which abate the speed of digestion.[1] This combination of appliances renders our plan of feeding more elastic, more adaptable to variety of individual health and constitution, and to variety of external conditions.[2]

During the early periods of life retardation of digestion is less required than in the adult state, because the growing organism can more fully utilise, in the work of the building up of the framework, any excess of food

[1] A slow digestion is quite a different thing from an imperfect digestion; indeed, it has seemed to me that dyspeptics sometimes suffer not from a too slow but from a too hurried digestion.

[2] The practice of the Irish peasant to underboil his potato, so as to leave a 'stone,' as it is said, in the middle of it; and the practice of the Scotch peasant to undercook his oatmeal—for he makes his 'brose' not by boiling, but simply by pouring boiling water on the meal—both these practices seem designed to check the speed of digestion, and thereby to enable the meal to 'stay' the stomach for a longer period.

which is poured into the blood. Accordingly we observe that retarding agents (tea, coffee, and alcoholic beverages) are not used at all, or only used sparingly, by infants and children.

If this view of digestive retardation in the stomach be well founded, the stomach becomes in some degree a storage organ for food—like the crop of birds, the paunch of ruminants, the dilatable cheeks of monkeys, and the pouch of the pelican.

Use of Salt.—Why do we use so much salt with our food? Animals in a state of nature require none. They find (with most rare exceptions) all the salt they require in their natural food; but cooks are always adding salt in their culinary operations, and we have it nearly always on our plates. This habit is probably dependent on the elaborate preparation and cooking to which we subject our food. In the preparation of flour the wheat is robbed of its outer coating, or bran, which contains the larger part of the saline matters of the grain. Potatoes and green vegetables are boiled in large quantities of water, and are thereby deprived of their saline ingredients. Meat and fish are boiled or roasted, and thereby lose some of their mineral constituents. Salt must therefore be supplied artificially to make up the defect, and to restore to the food so treated that sapidity and salinity of which it has in part been deprived. It has been remarked that tribes and races which subsist chiefly on a vegetable diet have more need of salt than meat-eating communities.

EFFECT OF FOOD-ACCESSORIES ON PANCREATIC DIGESTION.

The effects of the food-accessories on pancreatic digestion must obviously be less important, and also more

difficult to estimate, than in the case of salivary and peptic digestion. These accessories undergo changes in the stomach; alcohol and saline matters are largely absorbed in that viscus, so that the beverages containing them are considerably modified by the time they reach the duodenum. And not only are the accessories altered by their sojourn in the stomach, but the articles of food are also profoundly altered. Digestion is already half accomplished, the solid proteids are partly reduced to a state of solution, and the entire gastric mass is converted into a more or less homogeneous chyme. When this enters the duodenum it encounters the alkaline secretions of the liver and pancreas. A large part of the dissolved matter is reprecipitated by the neutralisation which then occurs, and the whole digesting mixture becomes alkaline in reaction. The digestion of starchy matters, suspended in the stomach, is now actively resumed; the digestion of the undissolved proteid matters which came through the pylorus, and of the neutralisation precipitate, recommences and proceeds to its final termination.

Pancreatic digestion appeared in my experiments, except in the cases of milk and farinaceous matters, to be essentially slower than gastric digestion. On meat and fish fibre and on egg-albumen pancreatic extract acted with extreme slowness, but on milk the action was extremely rapid—so likewise on bread. The agency of the stomach seems especially necessary for the digestion of all kinds of meat.

In considering the effect of food-accessories on pancreatic digestion we have to distinguish between the diastasic and the tryptic action of pancreatic juice.

Effect of Food-accessories on Pancreatic Diastase.—The action of alcohol on the pancreatic digestion of starch was found to be identical with its effect on salivary diges-

tion (see p. 24). In regard to wines and beer, it was found, as explained in a preceding lecture, that their inhibitory influence on the action of salivary diastase was entirely due to the acidity of these beverages. The same is the case with their action on pancreatic diastase—and as this acidity is removed by the alkaline juices of the duodenum, these beverages are without any effect on the pancreatic digestion of starch. In the case of tea the reaction of the medium also governs the result. For, although tea is highly inhibitory of pancreatic, as of salivary, amylolysis, this inhibitory action is removed (or almost removed) by changing the reaction from neutral or faintly acid to alkaline. When therefore tea passes into the alkaline atmosphere of the duodenum it ceases to have any effect on the pancreatic digestion of starch, or at least any effect of practical significance.

Effect of Food-accessories of Tryptic Digestion.—I tested experimentally the effect on tryptic digestion, of milk, of alcohol, and of tea and coffee. Alcohol had a distinctly retarding influence when its proportion in the digesting mixture rose to 5 per cent. of absolute alcohol (10 per cent. of proof spirit), but the effect was comparatively slight. The digestion of milk (other conditions being equal) was delayed by 10 per cent. of proof spirit from the normal of twelve minutes to eighteen minutes.[1] Even with twice this proportion of alcohol, digestion went on without any embarrassment, but the time of its completion was prolonged from the normal of twelve minutes to forty-five minutes. When we consider how rapidly alcohol is absorbed from the stomach it is obviously almost impossible that the chyme in the duodenum should ever

[1] For the method of estimating the effect of pancreatic extracts on the digestion of milk, I must refer the reader to the author's paper on this subject published in the Proceedings of the Royal Society for 1881.

contain anything like these proportions of alcohol, so that we may consider that alcohol, as used dietetically, never interferes with tryptic digestion.

Nor did I find that tea or coffee, even in the proportion of 50 or 60 per cent. of the digesting mixture, had any effect worthy of note. A slight retardation was observed, but not the slightest sign of embarrassment.

The results obtained with milk were controlled by experiments made with bread, with meat, and with fish-fibre—all of which yielded conformable results.

It may therefore be concluded that with regard to pancreatic digestion the effects of food-accessories are practically *nil*. In no case did I find evidence of the possibility of that embarrassment and arrest which occurred in so many instances in the case of salivary and peptic digestion.

On the Clinical Relations of Gastric and Intestinal Digestion.—In forming a plan of dietary for the sick, distinction must be made between gastric and intestinal digestion. In healthy persons, and invalids of the slighter sort, we must have regard mainly to gastric digestion; but in the seriously sick the stomach becomes often inoperative, and digestion becomes almost exclusively intestinal. The sympathy of the stomach with the general condition of the system is much more active and close than that of the intestine; the former organ approximates more nearly to the animal life of the body, the latter more nearly to the vegetative life. The seriously sick, and especially the febrile sick, are often quite unable to take solid food. When the appetite and power of taking food fails, it fails first with regard to meat, which is, so to speak, the speciality of the stomach, and next in regard to bread. Patients are then reduced to the use of liquid food—milk, beaten-up eggs,

gruels, jellies, beef-tea, and the like. In this latter condition the stomach loses its normal office, and becomes merely a conduit to pass on the liquid food to the duodenum—a continuation, as it were, of the œsophagus. Not perhaps that there is, except in extreme cases, an absolute abeyance of gastric secretion and gastric action, but they are reduced to so low an ebb that they count for practically nothing in the work of digestion. In this state of things, when patients are unable to take any solid food, it is quite wonderful to observe, in many cases, that persons who in health were unable to digest milk, or only to digest it with pain and difficulty, are able during illness to take milk in any quantity. The reason of this is obvious. In a state of health milk must be dealt with in the stomach, and the casein is curdled into solid masses; these masses have to be broken up and to be more or less dissolved in the gastric juice before they can traverse the pylorus. In the seriously sick, with an almost paralysed stomach, milk is not meddled with in that viscus. There is neither pepsin nor acid to curdle it, and it passes as a flowing liquid into the duodenum. Arrived there it encounters the secretion of the still active pancreas, and, as I have before remarked, milk is especially amenable to the action of the pancreatic juice. This, I believe, is the reason why in feeding the sick who are unable to take solid food our prime reliance is, and has always been, on milk. For milk is by far the most nutritive as well as the most complete and perfect of all liquid foods—containing, as it does, about 4 per cent. of proteid matter, 5 per cent. of carbohydrates (sugar of milk), and 5 per cent. of a highly emulsionated fat. There is no article at all comparable with it in respect of its comprehensive nutritive value, and also in respect of its easy digestibility by the intestinal juices. Hence it

takes precedence of all articles of food for the seriously sick, who are unable to digest solid food.

In feeding the sick our first consideration should be whether we are aiming at feeding the stomach or feeding the duodenum. In the former case, when the patient can take solid food—and this is the diagnostic indication that the stomach still possesses digestive activity—our aim must be to administer meat, bread, eggs, &c., in a state most favourable for peptic digestion. The meat should be well cooked—by preference boiled. It should be finely comminuted either by perfect mastication in the mouth, or (if this be impossible) by pounding in a mortar or beating to a paste with a spoon, as in the preparation of potted meat. Beef-tea and soups should be used sparingly, as should likewise be tea, coffee, and alcoholic beverages. And of these last, the best adapted for weak stomachs are regulated quantities of ardent spirits or of the stronger wines or champagne.

On the other hand, when we are aiming at feeding the duodenum our chief reliance, as I have said, must be on milk, which may be administered in a score of ways with tea, coffee, cocoa, spirits, soups, gruels, &c. Alternately with the various preparations of milk may be administered meat-teas, beaten-up eggs, cold-made meat infusions, and jellies.

LECTURE V.

ON THE ACID DYSPEPSIA OF HEALTHY PERSONS.

SUMMARY:—General description — Symptoms — The acid residuum — Nature and source of the acid—Particular symptoms—Pain—Depression—Acid eructations and heartburn—Flatulence—Gastric cramp or paroxysmal pyrosis—Diagnosis of acid dyspepsia—Further incidents of acid dyspepsia—Treatment—Treatment by provoking salivation.

GENTLEMEN,—

THE dyspepsia of healthy people may be divided into the *atonic* form and the *irritative* or *acid* form. In the former there is defect of digestive power—that is to say, deficiency of gastric juice and deficiency of muscular action in the stomach. In the latter there is an undue secretion or an undue accumulation of acid in the stomach, especially towards the later stages of digestion. The former, or atonic dyspepsia, scarcely merits the name of dyspepsia; it is rather an oligo-pepsia or apepsia; it is a defect rather than a disorder of digestion, and is often painless. It generally constitutes a part of some general ailment or debility, and is met with in the anæmic and in persons of low vitality, with feeble appetite, and slender powers of taking food.

Acid dyspepsia, on the other hand, is often seen in persons of strong constitution and good health, who work hard, are never laid up, and who live as long and are as good lives as their non-dyspeptic brethren. This form of dyspepsia is apt to trouble those who lead studious or sedentary lives; but it is by no means un-

common among farmers and those who lead an open-air life, especially if they belong to gouty families.

Acid dyspepsia is often, perhaps generally, associated with undue sensitiveness of the stomach (gastrodynia); hence there is frequently a certain commingling of symptoms—of symptoms due to mere hyperæsthesia and of symptoms due to disorder of the digestive process. Neurotic and hysterical individuals, both male and female, are very liable to gastric pains; although their digestion may be normal, their 'neurotic centre,' if I may be allowed the expression, is in their epigastrium; and their symptoms imitate those of true acid dyspepsia. In these cases of 'false dyspepsia,' as they may be termed, there is generally much complaint of flatulent distension, with noisy demonstrative eructation of gas, but without any real excess of acid in the stomach.

The acid dyspepsia of healthy persons consists essentially in a tendency or predisposition of an enduring character, the tendency being towards a generation or accumulation of excess of acid in the later stages of gastric digestion. The tendency is more or less permanent, and lasts with many persons from youth to age. It is rare in boyhood and girlhood, and tends to diminish in old age. It prevails at its maximum during the flush of manhood, and is distinctly more common among men than women. To a certain extent acid dyspepsia may be regarded as an ill-directed vigour of digestive action, as is well illustrated by the following incident. A habitual dyspeptic, who regularly suffered from painful excess of acid after each meal, on one occasion partook of an unusually heavy dinner, which proved too much for his digestive powers. After some hours of discomfort the meal was expelled with violent vomiting. This attack was followed by marked prostration of the gastric powers.

During the ensuing forty-eight hours there was a state of oligopepsia, with diminished appetite, but each meal was digested with perfect comfort and without the least excess of acid. At the end of two days the appetite and digestive vigour returned, and with their return came also the dolorous incidents of acid dyspepsia.

With most dyspeptics their trouble is not altogether continuous. They have their good periods and their bad periods. During their good periods they may for weeks or months go on digesting their meals with the same comfort as their more fortunate brethren. Then again for weeks or months their condition is one of almost incessant and severe suffering. It may even become serious, and lead to loss of appetite, inability to take a due quantity of food, and to consequent emaciation and loss of strength. But as a rule the dyspeptic, in spite of his torments, maintains his flesh and bodily vigour unimpaired.

Symptoms.—The subject of acid dyspepsia generally takes his food with appetite, sometimes even with voracity. The early periods of digestion are also generally easy and comfortable, but after a while there is felt a weight and aching at the pit of the stomach, which often increases to a severe pain. Then succeed a sense of fulness and tightness in the epigastrium, repeated and copious discharge of flatulence, with eructations of sour liquid into the mouth, and tendency to nausea or, more rarely, actual vomiting. These symptoms come on earlier after a light meal than after a heavy meal. After breakfast the symptoms often appear very speedily—in half an hour or an hour—whereas after dinner they are usually postponed for one, two, or three hours. In very sensitive dyspeptics a glass of sherry or a basin of soup will appear to 'turn sour' in fifteen or twenty minutes.

There is generally with dyspeptics of this class an impression that their digestion is abnormally slow. I doubt whether this is really so. I think that digestion in these cases is, often at least, hurried, and consequently imperfect; and that, after the main act of digestion is over, there remains in the stomach a large residuum of an acid mucus, mixed with remnants of food, chiefly composed of fatty matter. This sour mass seems difficult to dispose of; it lingers long in the stomach, and gives a feeling of unpleasant fulness and distension, which does not really correspond with any actual excess in the bulk of the gastric contents. At length, however, this residuum is got rid of, and the stomach becomes empty and at rest; the pain and discomfort wear off, and there is peace for the dyspeptic until after the next meal; then comes a repetition of the same events.

Not unfrequently the acid residuum is not entirely got rid of when the next meal-time arrives, and hence sour eructations may be experienced *immediately* on taking the new meal, confusing the symptomatology. In this case the sour mucus, for a short space of time, floats on the surface of the new meal, and the eructations are consequently acid to the taste; but presently it mingles with the meal, and the degree of acidity of the total gastric contents is thereby reduced (by dilution), and the eructations cease to be sour. Hence it is that the ingestion of a meal sometimes relieves the dyspeptic for a while; and this often happens with an accidental 'fit' of acid dyspepsia in persons who are not habitually predisposed thereto. They are cured, much to their surprise, by taking a full meal—the fact being that the new meal gives the surplus acid work to do—and so ends the attack.

The secondary, or sympathetic symptoms associated

with acid dyspepsia are sometimes very puzzling to the inexperienced, and apt to lead him astray in regard to their real nature. There are pains of a neuralgic character and abnormal sensations in various parts of the body —in the gums, in the head, in the bowels, or indeed anywhere—cold feet, flushings of the face, lassitude, abnormal sleepiness, palpitation of the heart, and so forth.

The Acid of Acid Dyspepsia: its Nature and Source.— Being myself subject to occasional periods of acid dyspepsia, in typical form, I have had several opportunities of examining the sour residuum which accumulates in the stomach toward the later stages of digestion. When this is thrown on a filter a perfectly clear pellucid acid liquor comes through, not containing any trace of organisms. The degree of acidity was found to vary through a considerable range. The results of analysis on six several occasions gave the following degrees of acidity, expressed in terms of dry hydrochloric acid (HCl):—

0·15 per cent. HCl	0·30 per cent. HCl
0·26 per cent. HCl	0·31 per cent. HCl
0·28 per cent. HCl	0·36 per cent. HCl

These numbers indicate a considerable excess in degree of acidity of the gastric contents.[1] Pure gastric juice (human) is estimated to have an acidity of 0·2 per cent. HCl, but this is considerably higher than the actual acidity of the contents of the stomach during normal digestion. According to the observations of Richet on a young man with gastric fistula (made arti-

[1] Reichmann found in cases of acid dyspepsia still higher degrees of acidity than those recorded above; namely, 0·34 per cent. and 0·45 per cent. HCl. On the other hand, Dr. McNaught found lower degrees—ranging from 0·09 per cent. to 0·2 per cent. HCl.—*Medical Chronicle*, vol. i. pp. 420 and 330.

ficially for the relief of impassable stricture of the œsophagus) the mean acidity of the gastric contents during the entire period of digestion was 0·17 per cent. HCl. But the variations were very great, and oscillated between 0·07 per cent. HCl on the one side and 0·3 per cent. HCl on the other.[1]

The nature of the acid in the sour residuum is not always the same. It seems to be a variable mixture of hydrochloric and diverse organic acids in varying proportions. The kind and proportion of the organic acids must depend mainly on the composition of the preceding meal. Lactic and butyric acids are probably the organic acids most commonly present. The latter is certainly often present, and can be recognised by its peculiar acrid smell and taste. The discrimination of the organic acids from hydrochloric acid, when both are present together in a solution containing proteid compounds, is very difficult; and the tests in vogue (shaking up with ether, trapæolin, and methyl-violet) are by no means trustworthy. As this point is of interest and under inquiry, I may relate how I convinced myself that the acid of the sour residuum of acid dyspepsia was not (in the sample examined) unmixed hydrochloric acid. In the course of my inquiries I had occasion to investigate the effects of acids on diastasic action; and I found that organic acids had considerably less inhibitory power on starch digestion than mineral acids of the same saturating equivalence. Now on comparing the inhibitory effect of pure dilute hydrochloric acid with that of the acid contained in the sour residuum it was found that for the same saturating equivalents hydrochloric acid had more than double the inhibitory power of the acid of the sour residuum.

[1] Richet, *Du Suc Gastrique*, Paris, 1878.

The *source* of the acid in acid dyspepsia has been much debated. I have long since come to the conclusion that it is exclusively derived from excessive secretion or accumulation of gastric juice, and not from any fermentive process. The sort of windy turmoil which goes on in the stomach of the dyspeptic has led observers too hastily to the analogy of vinous fermentation. A more precise examination of the incidents of acid dyspepsia lends no support to this view.

Fermentive processes, whether toruloid or bacterial, cannot, I think, take place in the stomachs of healthy persons to an extent sufficient to have a practical bearing: they can only take place to this extent in cases of pyloric obstruction or of chronic dilatation, when the food is detained in the viscus for a very long time—for twenty-four, or forty-eight hours, or longer.

Fermentive changes are altogether too slow to account for the rapid development of acid and flatulence in cases of acid dyspepsia. The two following experiments show how very gradual is the development of acid in bacterial fermentation :—

(*a*) Two ounces of the sour eructation from a typical case of acid dyspepsia were carefully neutralised with caustic soda, and then set aside in the warm chamber at blood-heat. After four hours only the feeblest acidity —amounting to 0·018 per cent. HCl—was developed. Bacteria were found under the microscope in scanty numbers, evidently only beginning to swarm.

(*b*) Two fluid drachms (7 c.c.) of the same sour eructation were mixed with twelve ounces (340 c.c.) of warm bread and milk. The whole mixture was now faintly acid=0·012 per cent. HCl. In two hours the acidity had not appreciably altered. In five hours the acidity had increased to 0·015 per cent. HCl, and at the

end of twenty-four hours (during the whole of which period the mixture had been maintained at blood-heat) the acidity had only risen to 0·035 per cent. HCl. In neither case was there any appreciable production of gas. The presence of organic acids in the acid residuum is easily accounted for without calling in aid the agency of fermentation. For, as has been explained in a previous lecture, salts of the organic acids, present in the articles of food, are decomposed by the hydrochloric acid of the gastric juice—chlorides of the bases are formed, and the organic acids are set free. In this way the occurrence of lactic, butyric, tartaric, malic, and other organic acids in the sour residuum is easily and naturally accounted for.

Particular Symptoms.—The most common and characteristic symptoms of acid dyspepsia are *pain, depression, acid eructations and heartburn, flatulence,* and *gastric cramp or paroxysmal pyrosis.* To each of these symptoms I propose to devote a few words.

Pain.—The dolorous sensations about the epigastrium, which often extend upwards to the lower sternal regions, are essentially due to the irritating action of the acrid and acid residuum on the mucous membrane of the stomach. This is the main and true explanation of the pain. But in the subjects of acid dyspepsia, especially during their bad periods, the stomach is unusually sensitive; and a residuum which would not be felt during their better periods, nor in non-dyspeptics, causes acute sensations. The severity of the pains (apart from varying sensitiveness of the stomach) depends (*a*) on the degree of acidity; the sourer the residuum is, the greater is the smarting caused by it; (*b*) on the proportion of butyric acid contained therein; for butyric acid is much more acrid than so much lactic or hydrochloric acid; (*c*) on the quantity or volume of the residuum. If the quantity be

small—only one or two ounces—there may be no pain though the acidity be high; on the other hand, if the residuum be large it may cause pain though its acidity be not excessive; because the extent of mucous surface brought into contact with the irritating fluid affects the degree of sensation produced. Just as with the impression of hot water on the skin, the dolorous sensation varies proportionately to the extent of surface exposed; the finger can easily tolerate immersion in a degree of heat which would be quite unbearable to the whole arm.

During the bad periods the pain and aching at the epigastrium linger after the stomach is empty, so that the discomfort is almost continuous.

Depression.—There is often a pronounced sense of depression. In neurotic individuals this is spoken of in exaggerated language. It is described as a horrid torment; they say that their life is made miserable, and not worth living. This constitutes what has been known of old as hypochondria. The pain and physical discomfort in the epigastrium appear to me quite sufficient to account for this depression, without invoking the aid of any poisonous alkaloid, formed during the digestive process. There is a peculiar bitter principle, produced during both the gastric and pancreatic digestion of proteids;[1] but this is a normal product, and there is not the least evidence that it possesses poisonous properties.

Acid Eructations and Heartburn.—These are usually prominent symptoms of acid dyspepsia, but are not invariably present. There is a regurgitation into the mouth of sour liquid from the stomach with discharge of flatulence. The savour of the eructation may be simple sourness, like that of lactic or hydrochloric acids,

[1] I called attention to the production of this bitter principle in my Lum'eian Lectures 'On the Digestive Ferments,' 2nd edit. p. 55.

but often it has a burning, acrid quality—this occurs when butyric acid is contained in the residuum. Butyric acid is volatile, and rises in acrid fumes, which affect the cardia and œsophageal orifice of the stomach and cause a persistent feeling of heat and horrification, with a nauseating tendency. This constitutes true heartburn. The occurrence of heartburn with the presence of butyric acid requires no intervention of butyric fermentation to explain it. Milk, butter, cheese, and other fatty food, all contain more or less butyric acid, either free or in combination. The butyrates are decomposed (as previously explained) by the hydrochloric acid of the gastric juice, and butyric acid is liberated in the free state. But how, therefore, it may be asked, is not heartburn a more constant incident of acid dyspepsia? The reason probably is, that, to produce a sensible quantity of butyric acid the butyrates must be present in the meal in considerable amount, as in rancid butter and other rancid fats often used in cooking, and secondly that the acid in excess must be hydrochloric acid, and not merely lactic or other organic acid—otherwise the butyrates are not decomposed—and the proportion of mineral to organic acid in the sour residuum varies a good deal.

Flatulence.—This is an invariable accompaniment of acid dyspepsia. The accumulation of gas in the stomach causes a sense of fulness and distension and an importunate desire to get rid of the accumulation by upward discharge. This importunity is intensified by the hypersensitiveness of the stomach, which is impatient of an amount of gas which would not incommode it, nor require upward discharge, but would be otherwise disposed of, perhaps through the pylorus, if the stomach were less sensitive. The occurrence of butyric acid also aggravates the gastric discomfort. The vapour of this acid, when it is

largely present in the residuum, must be always rising into acrid fumes in the warm atmosphere of the stomach. But apart from hypersensitiveness of the organ, and apart from the vapour of butyric acid, there is undoubtedly an abnormal generation or accumulation of gas in the stomach in acid dyspepsia. What is its source? The fermentation theory, as already explained, is wholly inadequate to account for it, and we are driven to other modes of explanation. My impression is that the accumulation of gas in acid dyspepsia may be traced to three sources. (*a*) *Swallowed air.* There is a large amount of air entangled and swallowed during the deglutition both of food and of saliva. The air engulfed with food is not larger in acid dyspepsia than in non-dyspeptics, but in regard to that swallowed with saliva there is a difference. During the existence of excess of acid in the stomach there is a certain amount of unconscious salivation going on, and a larger amount of air is thereby carried down than in the normal state. (*b*) *Liberation of carbonic acid in the stomach.* The saliva secreted during the period of surplus acid in the stomach is much more alkaline (from carbonate of soda) than when the contents of the stomach are neutral or only moderately acid. I have found this to be constantly the case; sometimes the alkalescence of the saliva is so high as to occasion visible effervescence on the addition of an acid. When the stomach is empty and neutral the saliva then secreted barely turns the colour of litmus paper, but when the organ contains excess of acid I have found the alkalescence of the saliva equal to 0·04 per cent. HCl. When this alkaline saliva, secreted in unusual profusion, descends into the stomach, it encounters the acid residuum, and is neutralised thereby with liberation of a certain amount of carbonic acid. I shall return

to this point when I come to the treatment of acid dyspepsia. (*c*) *Regurgitation of carbonic acid from the duodenum.* This is a third probable source of gas in the dyspeptic. When the chyme passes through the pylorus it encounters the secretions of the liver and pancreas, both of which are alkaline from carbonate of soda. The collision must liberate carbonic acid. We may regard it as probable that when the contents of the stomach are super-acid the biliary and pancreatic secretions are, as in the case of the saliva, super-alkaline, and that consequently a larger disengagement of carbonic acid occurs in the duodenum under such conditions than in tranquil digestion. The gas thus generated would unduly distend the duodenum, and would probably push its way partly upwards through the pylorus into the stomach, and partly downwards into the jejunum.

It has been suggested, as a partial source of gas in acid dyspepsia, that carbonic acid is exhaled from the blood through the mucous membrane of the stomach (as in the process of respiration through the pulmonary membranes), but I do not see why this should occur in a larger degree in dyspeptics than in other healthy persons. I can, however, easily believe that in regurgitant heart disease and in general emphysema, when there is severe venous stasis in the stomach, and a cyanotic state of the blood, such exhalation of carbonic acid through the gastric mucous membrane may take place, and that this accounts for the distressing flatulent distension which is so common in these affections. But in acid dyspepsia the blood is not surcharged with carbonic acid, and there is no venous stasis in the stomach.

Gastric Cramp or Paroxysmal Pyrosis.—The course of acid dyspepsia is sometimes diversified by the occurrence of a very peculiar and characteristic symptom, which,

though brief in duration, is very distressing, and even alarming to the uninitiated. This symptom consists in a paroxysm, of which the chief features are sudden cramp of the stomach with sudden profuse salivation. The attack only lasts half a minute or a minute, but to the sufferer the time appears long. I would suggest that the word *pyrosis* be confined to these essentially paroxysmal attacks. Writers on dyspepsia exhibit confusion in the use of the term pyrosis, and give it a mixed description, which includes partly these paroxysms and partly the ordinary symptoms of acid dyspepsia and heartburn. The gush of saliva into the mouth is often misunderstood, and is described as a regurgitation from the stomach or from the lower part of the œsophagus.

Paroxysmal pyrosis is essentially an abortive and incomplete act of vomiting. Complete vomiting consists of the following succession of events :—Gastric spasm, profuse salivation, convulsive spasm of the abdominal muscles, sudden downward thrust of the diaphragm, closure of the glottis, opening of the cardia, and finally ejection of the contents of the stomach. The abortive act which constitutes a paroxysm of pyrosis falls short of the complete act in the downward thrust of the diaphragm, also in the opening of the cardia ; moreover, the contraction of the abdominal muscles is either absent altogether or is cramp-like rather than convulsive ; the voice is reduced to a whisper, ut is not altogether suppressed, so that the closure of the glottis is not absolute ; and there is no ejection of the contents of the stomach. Occasionally, however—but this is quite exceptional—the paroxysm does culminate in actual vomiting. The sense of nausea is imperfectly developed in these attacks. The gush of saliva is something tremendous—often greater than incessant swallowing efforts can dispose of—and the

surplus flows out abundantly from the mouth. Some persons are not conscious of swallowing any of it, and believe that they let it all flow out at the mouth. A paroxysm of this kind only occurs during the presence of surplus acid in the stomach, and on its conclusion there is a sensible relief (for a time) to the previously existing epigastric pain and other symptoms of acid dyspepsia.

I have had several opportunities of examining the fluid that gushes into the mouth in paroxysmal pyrosis, both in my own case and in that of patients. It invariably possesses the character of true saliva, differing only in its unusual degree of alkalescence. I will give two examples. The first is from my own person. During a typical attack of gastric cramp I succeeded in collecting some of the fluid which flowed in an abundant stream into the mouth. Its alkalinity was equal to 0·125 per cent. HCl; it effervesced distinctly with acid. In diastasic power it was more active than average healthy saliva—in the proportion of 12 to 8. The second example was from a patient who was subject to recurrent and severe attacks of paroxysmal pyrosis. On close questioning this patient he insisted that the fluid which came into, and flowed out of, his mouth during the paroxysm came from the stomach. He was quite sure that it was not a rush of fluid into the mouth from the sides of the mouth itself. I requested him to send me on the next occasion some of the ejected fluid in a bottle. He did so. I found it, as I had expected, to possess all the properties of true saliva, with excess of alkali. Its alkalinity was equal to 0·15 per cent. HCl, which corresponds very closely with the grade of acidity of the gastric contents during tranquil digestion. Its diastasic activity was fully equal to that of fresh normal saliva,

as tested by standard starch mucilage in the manner described in my second lecture.

I cannot therefore doubt that the gush of fluid in paroxysmal pyrosis is purely and exclusively a gush of saliva.

The relief which commonly follows a paroxysm is obviously due to the large quantity of alkali introduced into the stomach with the gulped saliva.

The paroxysms of pyrosis occur quite irregularly—rarely more than once in one day, more generally once in two or three days, sometimes only once a week, or once a month, or even once a year. Some dyspeptics never experience these paroxysms. They occur exclusively during the presence of excess of acid in the stomach, but they are not infrequently provoked by an impression of cold, or a chill.

Diagnosis of Acid Dyspepsia.—The diagnosis of acid dyspepsia is in principle perfectly simple. If the dolorous sensations at the epigastrium are relieved by a dose of carbonate of soda, or any other alkali, the case is one of acid dyspepsia. Such a dose, as habitual dyspeptics know well, infallibly gives relief. The relief may not be quite complete, but it is always marked and speedy. If no such relief is given the case is certainly not simply one of acid dyspepsia. In neurotic and hysterical individuals the diagnosis is not always so easy, because such persons give a confused, often discrepant, account of their sensations, and are bad subjects for this kind of crucial experiment.

When the dyspeptic takes a dose of soda early after a meal the relief is only temporary, and does not serve until the next post-cibal emergency; but if he takes his dose late the relief lasts until after the next meal, and the subsequent eructations are perceived to have lost their sour and acrid taste.

Further Incidents of Acid Dyspepsia.—Slight meals are sometimes more provocative of acidity than full ones. A meal taken at an unusual hour, or a full meal eaten at an hour when usually a light meal is taken, is also very apt to provoke acidity. Surplus acidity is provoked by anything that renders the meal more difficult of digestion, such as imperfect mastication or hurried eating. As a rule, careful 'dieting' is of no avail, or only of partial avail, in acid dyspepsia. Constipation of the bowels distinctly intensifies the symptoms. Almost all habitual dyspeptics have their special lædantia and juvantia, and to none is the old proverb more applicable that 'one man's meat is another man's poison.' Some cannot take sugar, others can take it freely; the same with eggs, with soup, with various wines and beer, with tea, coffee, some kinds of meat, with potatoes, and so forth. Fatty matters disagree very generally. The dyspeptic stomach is peculiarly capricious and peremptory, and, as a rule, there is very little use in arguing with it in regard to its likings and dislikings.

The appetite is usually good; dyspeptics often enjoy their meals and 'could eat more' were it not for fear of the consequences. Sometimes the appetite is voracious; sometimes, on the contrary, the appetite is weak or capricious.

Treatment.—The treatment of cases of habitual acid dyspepsia divides itself into—(*a*) means which are directed to obtain relief from present discomfort; and (*b*) means which aim at curing the disorder, or at least at shortening the bad periods. The bias or tendency is, as I have before remarked, more or less enduring; but if you can cut short the bad periods, this is nearly as good as complete cure, because the ailment can thereby be controlled and, practically, nullified. For immediate relief there is nothing

better than a dose of carbonate of soda; 5 to 10 grains of soda bicarbonate dissolved in water almost at once allay the suffering, by saturating the gastric acid. A copious upward discharge of carbonic acid follows such a dose. Other alkalies answer the purpose equally well—magnesia, chalk, or carbonate of potash. Many dyspeptics have learnt this secret, and carry with them a supply of little compressed tablets of bicarbonate of soda, which they use after their meals. An equally good resource is supplied by the bicarbonate of soda lozenge, or the bismuth lozenge, of the British Pharmacopœia. The former contains 5 grains of soda in each lozenge; and the latter contains, besides the bismuth, to which it owes its name, 6 grains of the mixed carbonates of lime and magnesia.

The use of alkalies, however, is scarcely at all curative in cases of habitual dyspepsia. For an accidental 'fit' of dyspepsia a few doses of an alkali, or even a single dose, may suffice; but alkalies do not appreciably cut short the bad periods of habitual dyspepsia. The symptoms return with unabated severity after the next meal, and so the dyspeptic contracts the habit of taking regularly a dose of alkali after his meals, and this may go on for many years. Is there any harm in this practice? I am not quite sure; it is certainly a highly unnatural habit: the urine is thereby rendered abnormally alkaline, and this signifies that there is, for a time, an abnormal alkalescence of the blood. I have sometimes suspected that this might lead to mineral degeneration of the arteries. This, however, may be only a fancy of mine; it was put into my head by the observation of prematurely occurring apoplexy in two apparently healthy persons who, I knew, had been in the habit for many years of taking soda regularly after their meals for the relief

of acid dyspepsia. At any rate, it seemed very desirable to find some more curative method of managing acid dyspepsia than by exhibiting endlessly recurrent doses of alkalies.

Treatment by provoking Salivation.—Having found that during the prevalence of surplus acid in the stomach there coincided an increased flow of saliva, and that this saliva possessed an unusual degree of alkalescence, I was led to the idea that the saliva was the natural antacid of the stomach. On several occasions I was able to measure synchronously the alkalinity of the saliva and the acidity of the stomach; and I found that the proportion between them was such that six to eight volumes of the saliva would saturate one volume of the gastric acid. There does not, at first sight, appear to be much prospect of relief from this small proportion of salivary alkali. Nevertheless, when it is considered that complete saturation of the gastric acid is by no means necessary to procure relief, and that all that is required is that the acidity should be so reduced as to bring it within the limits of the normal acidity in tranquil digestion, the prospect looks much more promising. If the acidity in the stomach could be reduced one-fourth or one-third, these normal limits would be usually attained. And I think it highly probable that, in the usual course of events in acid dyspepsia, the descending stream of alkaline saliva does fulfil an important purpose. When the stomach contains an excessive quantity of sour residuum we may suppose that the pylorus is closed against its passage into the duodenum. This may be regarded in the light of a conservative act, and designed to prevent disturbance of the alkaline digestion in the duodenum by an overwhelming influx of acid from the stomach. But by the steady, continuous downward

flow of alkaline saliva the excessive acidity in the stomach is gradually lessened, and at length brought down to the normal grade, and then the refractory pylorus opens, and the stomach is relieved.

This train of ideas led me further to the notion that if the flow of this alkaline saliva could be increased, effective relief might thereby be given in acid dyspepsia, and that by acting in this way we should be operating more closely after nature's indications than by giving alkalies of extraneous source. We should be making the blood itself the source of the alkali, instead of taking it from the shop. And on trial I found the results conformable with the theory. Anything that increased the flow of saliva was found to abate the pangs of acid dyspepsia. Lozenges of all sorts promote a flow of saliva, but especially lozenges which contain a stimulating ingredient like ginger or cayenne. A very sensible relief is given to the dyspeptic by the use of these lozenges; and this is probably the secret of the habit of some country dames, who carry in their capacious pockets a root of ginger, to which they apply when the stomach aches. A step further led me to the use of simple gum-lozenges. The sucking or chewing of any kind of lozenge will promote salivation; the turning round with the tongue and the mastication of the little morsel, sets the salivary glands to work. Lumpy 'tears' of gum arabic, such as may be picked out from the druggist's stock, do not make bad lozenges for this purpose. The 'glycerine jujubes' of the shops likewise consist of nearly pure gum, and these are somewhat more palatable than the gum tears, and answer equally well, or better, as provokers of salivation. The sugar contained in them is, however, objectionable to some stomachs. I think a lozenge composed of gum, with the addition of a little pyrethrum,

might be a valuable addition to the resources of the dyspeptic.

By the use of lozenges, and especially of gum lozenges, I have obtained in the treatment of acid dyspepsia distinctly more curative results than by the use of alkalies. The advent of the bland gummy solution into the stomach probably acts topically as a soothing application to the irritated mucous membrane, allays its abnormal sensitiveness, and thereby disposes it to a more normal performance of its functions in dealing with the succeeding meal. If the surplus acid is great, and the torment severe, a dose of alkali must be administered; but the milder means here suggested will give adequate relief in most instances, and will greatly promote the abbreviation of the bad period.

With regard to the regulation of the diet of the dyspeptic, the removal of habitual constipation, the due mastication of the food, the avoidance of hurried eating, the use of exercise in the open air, and the adoption of other hygienic precautions, I have nothing to add to the rules laid down on these matters in your manuals and in special treatises on dyspepsia.

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